

DESIGN OF SEWERAGE SYSTEM FOR
HUNTLEY, MONTANA

BY

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ARMOUR INSTITUTE OF TECHNOLOGY

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for Huntley, Mont.

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1. *ANALYSIS OF READING*

2. *TEACHING METHODS*

3. *TEACHING MATERIALS*

4. *TEACHING AIDS*

A THESIS

PRESENTED BY

SAMUEL EMANUEL SOSNA
&
BENNO BENDIX SOSTHEIM

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

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HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN

CIVIL ENGINEERING

APPROVED:

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DESIGN
OF
SEWERAGE SYSTEM
FOR
HUNTLEY, MONT.

PREFACE.

In presenting this volume, the writers desire to express their sincere thanks to Professor Alfred E. Phillips, and to Mrs. Julia B. Beveridge; to the former for the many invaluable suggestions which he gave them, and to the latter, for the aid which she rendered in bringing much reference matter to their attention.

S. E.S.

B. B.S.

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DESIGN.

The town of Huntley, Montana, was brought to the attention of the writers by the extensive irrigation projects being carried on by the U. S. Government in that vicinity.

Several maps were procured from the U. S. Reclamation Service with the intention of choosing a town which offered a suitable problem of sewage collection. From this standpoint, Huntley was chosen.

Topographical maps of five foot contour interval were next obtained from the Reclamation Service. The map of Huntley was enlarged from a government map of 400 feet to the inch scale, to 200, and one foot contours were drawn interpolating from the above mentioned maps.

For a town of this size, separate systems of sewage and water collection would be impracticable; inasmuch, as the sewage would not have to be purified, but could be emptied into the Yellowstone River, bounding the town.

It was, therefore, decided to design a sewer system on the combined plan.

Referring to the map, it will be seen that the two railroads cross the entire length of town and join near the southwestern extremity. Beyond this junction would be the best crossing for the sewer, inasmuch it would be necessary to cross only one track. At all other places, at least four tracks would have to be crossed. Due to topographical reasons, however, the drainage being away from this point, crossing here would be impracticable. The crossing chosen offered the best solution. The rest of the sewer lay-out was governed by the following considerations:

Topography, Lot Frontages, Depth & Grades.

TOPOGRAPHY.

The entire general drainage was toward the northern end of the town; a ridge very close to and paralleling the river, dividing the drainage

into easterly and westerly directions.

The westerly drainage was comparatively insignificant, since it could directly reach the river, it was unnecessary to provide sewers for it. The easterly drainage was taken up at several points and brought back toward the river

LOT FRONTAGES.

It was aimed to have one sewer serve both sides of the street, although exceptions to this were necessitated by different considerations, among which the occupation of the streets by an irrigation canal figured prominently.

DEPTH.

The sewers were kept below about nine feet, in order to be below the ordinary basement level. The drainage from the northeasterly section had to be carried through very flat ground, making deep sewers imperative.

GRADES.

Wherever possible, the grades were placed at about 1 in 250, although they were often influenced by other factors.

QUANTITY OF DISCHARGE.

In computing storm water discharge, the quantity of domestic sewage flowing is comparatively so insignificant, as to make its effect negligible and it was, therefore, not reckoned with.

The areas drained were computed from the topographic map and the run-off assigned to different manholes, which were to have perforated covers to catch this.

In computing the run-off the McMath formula was used.

DIAMETER AND KIND OF SEWER PIPE.

The diameters were taken from diagrams based on Kutter's formula contained in Metcalf & Eddy's "American Sewer Practice". The values of "n" were taken as .00015 for concrete pipe, and .00013 for vitrified clay pipe.

For all diameters under 24", vitrified clay pipe was used and all sewers of over 24", were of concrete pipe, Lock Joint Pipe, type.

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Metcalf & Eddy, "American Sewage Practice",
Vol. 1.

H. N. Ogden, "Sewer Design"

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Sewage Disposal"

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Disposal".

TRENCHES.

1. LENGTH OF TRENCH.

Unless otherwise directed or permitted, not more than 120 feet of any trench in advance of the end of the built sewer shall be open at any time; and unless written permission to the contrary is given, the trench shall be excavated to its full depth for a distance of at least 25 feet more than the minimum length of sewer permitted to be laid in it. Trenches for house connections drains shall not be open on both sides of the street at the same time, unless permission has previously been given to close the street. Unless otherwise directed, each trench for basin connections and house connection drains shall be fully excavated for its entire length before any pipes are laid therein.

2. SHEETING AND BRACING.

Where necessary, the sides of the trenches and excavations shall be supported by adequate sheeting and bracing. Steel sheeting may be used only where shown on the plan or directed. Sheetings and bracing will be paid for only when left in place by written order, in which event the amount left in place will be paid for at the contract price for such material. Unless specially permitted, sheeting against which concrete is placed, shall not be removed, but such sheeting will not be paid for unless ordered to be left in place to protect the sides of the trenches and excavations. The Contractor will be held accountable and responsible for the sufficiency of all sheeting and bracing used, and for all damage to persons or property resulting from the improper quality, strength, placing, maintaining or removing of the same.

3. SHEETING IN SOFT MATERIAL.

Where the material to be excavated is of such a character or other conditions are such as to render it necessary, the sheeting shall be closely driven and to such depth below the bottom of the sewer as may be directed.

4. TUNNELING.

All work shall be done in open trenches or excavations; no tunnelling shall be done except with the consent of the Engineer.

5. TREES AND STUMPS.

The Contractor shall grub and clear the surface over the trenches and other excavations, of all trees, stumps, stones and any other incumbrances affecting the prosecution of the work, and shall remove them from the site.

6. MATERIAL TO BE INSPECTED AND DISINFECTED.

If required by the Engineer, any and all of the excavated material shall be satisfactorily disinfected or deodorized, or immediately removed from the work.

7. ROADWAYS, SIDEWALKS, etc., TO BE KEPT CLEAN.

Unless permission is given to the contrary the excavated material and materials of construction shall be so deposited, and the work shall be so conducted as to leave open and free for pedestrian traffic, all crosswalks, a space on each sidewalk not less than one-third the width of the sidewalk and not less than 3 feet in width, and for vehicular traffic, a roadway not less than 8 feet in width. All street hydrants, water gates, fire alarm boxes and letter boxes shall be kept accessible for use. Not more than 100 feet (linear) of sidewalk shall be used at any time for storage or materials from any one trench. During the

progress of the work, the Contractor shall maintain such crosswalks, sidewalks and roadways in satisfactory condition, and the work shall at all times be so conducted as to cause a minimum of inconvenience to public travel, and to permit safe and convenient access to private and public property along the line of the work.

8. SURPLUS MATERIAL.

If all of the excavated material cannot be stored on the street in such a manner as to maintain the traffic conditions hereinbefore specified, the surplus material shall be removed from the work and stored. After the construction the sewer, so much of this material as is of satisfactory quality and necessary for the purpose shall be brought back and used for backfilling the trench.

9. BACKFILL.

Where directed in built-up districts and in streets where traffic conditions render it necessary, the materials excavated from the first 8 feet of trenches shall be removed by the Contractor as soon as excavated, and the material subsequently excavated, if suitable for the purpose, shall be used to backfill the trenches in which the sewers have been built and neither the excavated material nor materials of construction shall be stored on the roadways or sidewalks.

10. FENCE.

Where required by the Engineer, suitable fences shall be placed along the sides of the trenches to keep the streets safe for traffic.

11. TEMPORARY BRIDGES.

Crosswalks, where intersected by trenches, shall if required, be temporarily replaced by substantial timber bridges not less than 3 feet wide, with side railings. Where required, suitable temporary bridges for vehicles shall be provided and maintained across trenches.

12. DISPOSAL OF WATER FROM TRENCHES.

The Contractor shall at all times during the progress of the work, keep the trenches and excavations free from water. Water from the trenches and excavations shall be disposed of in such a manner as will neither cause injury to the public health, nor to public or private property, nor to the work completed or in progress, nor to the surface of the streets, nor cause any interference with the use of the same by the public.

13. COST TO BE COVERED

The cost of all labor required to be done and all materials furnished in the performance of all of the work specified in paragraphs 1 to 12 inclusive, except as otherwise provided, shall be covered by all the contract prices for all the items for which there are contract prices.

EARTH EXCAVATION.**14. EARTH EXCAVATION**

shall include the removal of all material other than rock as defined in sections 21 and 22.

15. WIDTH OF TRENCH FOR SEWERS, etc.

The minimum width of trenches in earth for pipe sewers,

basin connections, house connctions and other drains not over 18 inches in diameter, shall be such as to give a clearance of 8 inches on each side of the barrel of the pipe, and for those of larger dimensions, of 10 inches on each side of the barrel of the pipe, and all such trencheshall have a clear width equal to the maximum widths of the cradles of the sewers to be laid in them , when such cradles are wider than the minimum widths hereinbefore specified. The minimum clear widths of trenches in earth for other sewers shall be the greatest external width of the structures including the necessary forms, to be built therein.

16. EXCAVATION FOR MANHOLES, etc.

Where a man-hole or other appurtenance or the foundation therefor extends beyond the exterior lines of the sewer or its foundation, the minimum excavation in earth required for the same shall be that contained in a prism with vertical sides and a horizontal section equal to the smallest rectangle which will enclose such appurtenance and its foundation.

17. EXCAVATION FOR RECEIVING BASINS, etc.

The minimum dimensions of the excavation in earth for orick receivng basins, catchbasins and flush tanks shall be such as to give a clearance inside the sheeting of 1 foot on all sides above the foundation, but in all such cases the excavation shall be large enough to include the foundation for the structures shown on the plan.

18. DEPTH OF TRENCHES.

Trenches shall be excavated to the depth required for the foundations

of the sewers and appurtenances shown on the plan, and where conditions are such as to make it necessary, to such additional depths as may be directed. Where pipe is laid without a cradle, the bottom of trenches shall be excavated to fit the lower third of the pipe, and excavations shall be made to receive the hubs. All irregularities in the bottoms of trenches shall be filled up to the required grade with suitable material.

19. COST TO BE COVERED

(Same as paragraph 13,
except paragraph numbers.)

20. ADDITIONAL EARTH EXCAVATIONS.

When there is a contract price for additional earth excavation, it shall cover the cost of excavating all material (other than rock) ordered to be excavated beyond the lines and depths herein specified in sections 15 to 18, inclusive, and also the cost of excavating all material within the lines of the trenches above the surface of the ground as shown on the plan, when such material has not been placed there by the Contractor. This contract price shall also cover the cost of filling such excavations with approved material. Where no price is named in the contract for additional earth excavation, the cost of the several items enumerated above, shall be covered by all the contract prices for all the items for which there are contract prices.

ROCK EXCAVATION.

21. DEFINITION.

Rock excavation shall include the excavation and removal of the following materials:

a. Rock which shall be determined to be of such a character as to warrant its removal by blasting, in order to insure prompt and proper prosecution of the work.

b. Boulders and pieces of rock, masonry in mortar, and concrete, each of which contains one-third cubic yard or more, except the masonry and concrete of old sewers and their appurtenances.

22. PIECES OF ROCK,

masonry, concrete or boulders, which fall or slide into the trench from beyond the lines thereof as herein defined, will not be measured, and the cost of the removal of the same shall be covered by all the contract prices for all the items for which there are contract prices.

23. WIDTH OF TRENCH.

The required width of trench in rock for pipe sewers, basin connection house connections and other pipes will be such as to give a clearance of 1 foot on each side of the pipe, exclusive of spurs and hoods; the required width of trench in rock for other sewers and drains will be such as to give a clearance of one foot on each side of the structure to be built therein at its greatest external width. Where a riser, manhole or other appurtenance or the foundation therefor, extends beyond the exterior lines of the sewer or its foundation, the excavation in rock, required for the same will be that contained in a prism with vertical sides and a horizontal section 1 foot wider on each side than the smallest rectangle which will enclose such appurtenances in its foundation. The required dimensions of the excavation in rock for receiving basins, catch basins and flush tanks will be such as to give a clearance of 1 foot

on all sides above their foundations.

24. DEPTH OF TRENCH.

The rock shall be excavated to the depths required for the cradles and foundations of the structures as shown on the plan, and not less than 4 inches below the outside of the barrel for the pipe sewers.

25. MEASUREMENT.

The volume of rock to be paid for will be that contained in prisms with vertical sides and of such dimensions as to give the widths and clearances hereinbefore specified from the bottoms of the trenches, as specified and as shown on the plan, to the surface of the rock.

26. ROCK STRIPPED.

Rock shall be stripped in sections, which unless otherwise permitted, shall be not less than 50 feet in length, and the Engineer shall then be notified in order that he may measure the same. Rock excavated or blasted before such measurements are made, will not be paid for.

27. EXCAVATION FOR BRANCHES.

Wherever a branch for a proposed sewer or extension of a sewer is built in the rock, the required trench shall be excavated for a distance of not less than 5 feet beyond the end of such branch, in the direction of the proposed sewer or extension.

28. BLASTING.

All blasting operations shall be conducted in strict accordance with existing ordinances and regulations relative to rock blasting and the storage and use of explosives.

Any rock excavation within 5 feet of a water main less than 36 inches in diameter, and within 10 feet of a water main 36 inches or more in diameter, shall be done with very light charges of explosives, or, if directed without blasting, and the utmost care shall be used to avoid breaking or disturbing the main.

29. EXPOSED STRUCTURES TO BE PROTECTED.

All exposed sewers, manholes, receiving basins and other structures shall be carefully protected from the effects of blasts. Any damage done to structures shall be promptly repaired by the Contractor at his own expense.

30. PRICE TO COVER.

The contract price for rock excavation shall cover the cost of all labor and materials required to excavate and remove all rock as specified, and without regard to its subsequent use. When there is no contract price for rock excavation, the cost of excavating and removing rock shall be covered by all the contract prices for all the items for which there are contract prices.

BACK FILLING.

31. BACKFILLING AROUND SEWERS.

Unless otherwise specified or directed, all trenches and excavations shall be backfilled immediately after the structures are built therein. For a depth of at least 2 feet over the top of the sewers, basins, connections, and other drains, the material used for backfilling trenches as excavated shall be clean earth, sand or rock dust. It shall be carefully deposited in

uniform layers not exceeding 6 inches in depth, and unless otherwise permitted, each layer shall be carefully and solidly tamped with appropriate tools in such a manner as to avoid injuring or disturbing the completed work.

32. BACKFILLING FOR REMAINDER OF TRENCH.-

Backfilling for the remainder of the trenches as excavated shall be approved material free from organic matter and containing no stones over 10 inches in their largest dimensions. Stones which are used in backfilling shall be so distributed through the mass that all interstices are filled with fine material. Backfilling shall be deposited as directed and unless otherwise permitted shall be spread in layers and solidly tamped.

33. BACKFILLING AROUND MANHOLES, RECEIVING BAS-
INS, etc.-

Backfilling within 2 feet of manholes, house connection drains, receiving basins, inlet basins, flush tanks and other structures shall be of the same quality as that specified in sections 31 and 32. It shall be uniformly deposited on all sides, and unless otherwise permitted, solidly tamped in such manner as to avoid injuring the structures or producing unequal pressures thereon.

34. PUDDLING.-

Backfilling shall, if required, be flooded or puddled with water as the work progresses, instead of being tamped.

35. CAVITIES FILLED.-

When sheeting is drawn,

all cavities remaining in or adjoining the trench shall be solidly filled. When sheeting is left in place, all cavities behind such sheeting shall be solidly filled as directed.

36. DEFICIENCY OF FILLING.-

Unless otherwise shown on the plan, trenches shall be backfilled to the height of the surface of the ground as it existed at the commencement of the work. Should there be a deficiency of proper material for the purpose, the Contractor shall furnish and place such additional material as may be required.

37. TEMPORARY BULKHEADS.-

For retaining backfilling only temporary bulkheads will be allowed. Such bulkheads shall not be of stone, and they shall be removed as the trenches are backfilled.

38. CURVES, BRANCHES, etc., NOT TO BE COVERED.-
Sewers built on curves, also drains, basin connections, house and sewer connections, and intersections, ends of sewers and branches shall not be covered until the Engineer shall have inspected, measured and located the same, and given permission to backfill the trenches over them.

39. REMOVAL OF SURPLUS MATERIAL.-

As trenches are backfilled, the Contractor shall remove all surplus material and regrade and leave free, clear and in good order, all roadways and sidewalks to within 50 feet of the end of the completed work. During the progress of, and un-

til the final payment for and acceptance of the work, he shall maintain in good and safe condition, the surface of the street over all trenches, and promptly fill all depressions over and adjacent to trenches caused by the settlement of backfilling. In case of failure or neglect on the part of the Contractor to comply with the requirements of this paragraph within 24 hours after the service upon him of a written notice so to do, the Board of Local Improvements may furnish all materials and do all the work required, and the cost thereof will be charged to the Contractor and deducted from any moneys due or to become due to him under this contract. All surplus material or any part thereof shall, if required, be deposited as directed on the streets and avenues within the limits of this contract where surfaces are below grade, and in such a manner as to leave the surfaces of the filled material even.

40. (Same as paragraph 13, except paragraph numbers.)

CEMENT.

41. CEMENT.-

All cement used in this work shall be high-grade Portland cement of well-established and approved brands and shall pass all the Specifications and Tests of the American Society of Testing Materials.

42. RE-TESTING.-

Any cement which shall have been kept in storage after testing for a sufficient time to warrant it, shall be re-tested. Any prior acceptance shall be considered void and the acceptance or rejection of the cement

shall depend upon the results of the latter tests.

43. APPROVAL OF BRAND MAY BE RESCINDED.-

The Engineer may at any time rescind the approval of any brand of cement that develops qualities which in his opinion unfit it for use in the work.

44. SAMPLES.-

The Contractor shall notify the Engineer of the arrival of cement on the work, and furnish such facilities as may be required for obtaining samples for testing. Samples will be taken so as to fairly represent the material. The number of packages sampled and the quantity to be taken from each will depend upon the importance of the work and the number of tests to be made.

45. DELIVERY AND STORING.-

Cement shall be delivered on the work in barrels or approved bags of uniform size with the brand and the name of the manufacturer plainly marked thereon, and shall be immediately stored in a dry place and carefully protected from the weather. A sufficient stock of cement shall be kept on the work in advance of the necessity for its use to permit of the making of the required sevenday tests. Except by written permission, no cement shall be used before it has been tested and accepted, and any concrete or masonry which may have been made under such permission with cement that is subsequently rejected, shall be removed and replaced with concrete or masonry made of accepted cement. All cement found to be of improper

or inferior quality shall be immediately removed from the site of the work.

46. COST TO BE COVERED.-

The cost of furnishing, storing, and incorporating cement in the work, and the cost of samples required for testing, shall be covered by the contract prices for the structures or classes of work in connection with which the cement is used.

SAND.

47. SAND.-

The sand shall be clean and sharp, free from dirt, loam, mica and organic matter, and shall contain not more than 8 per cent by volume of clay, and no clay shall be artificially added.

MORTAR.

48. COMPOSITION.-

All mortar used in the work, unless otherwise specified, shall be composed of 1 volume of cement, as in the original package, and 2 volumes of sand. Mortar used in the haunch walls of brick sewers shall be composed of 1 volume cement and 3 volumes of sand.

49. MIXING.-

Mortar shall be mixed in a suitable box or on a tight platform, and never upon the ground. The cement and sand shall be thoroughly mixed dry, until

the mixture has an uniform color. Clean, fresh water shall then be added and the mass worked until a mortar which is uniform and of the required consistency is produced. Mortar shall be mixed in no greater quantity than is required for the work in hand, and any that has set sufficiently to require retempering shall not be used.

50. FREEZING WEATHER.-

The mixing and use of mortar in freezing weather shall be subject to the same requirements as hereinafter specified for mixing and placing concrete under similar conditions.

51. COST COVERED.-

The cost of all labor and materials required to furnish and place mortar in the work, as specified, shall be covered by the contract price for the structure or class of work in connection with which the mortar is used.

CONCRETE.

52. CLASS A CONCRETE.-

Class A concrete shall be made of 1 part of cement, 2 parts of sand and 4 parts of broken stone or gravel. Broken stone for Class A concrete shall be hard, sound and durable and shall not contain loam, clay, organic matter, objectionable quantities of dust or other improper material. Broken stone for Class A concrete shall be the run of the crusher that will pass through a screen with circular openings 1 inch, 1-1/2 inch and 2 inches in di-

ameter. Gravel shall be of hard, sound, durable material equal in quality to that specified for broken stone.

53. CLASS B CONCRETE.-

Class B concrete shall be made of 1 part of cement, 2-1/2 parts of sand and 5 parts of broken stone or gravel. Broken stone, gravel and sand for Class B Concrete shall in all respects comply with the requirements specified for the same materials for Class A concrete.

54. CLASS C CONCRETE.-

Class C concrete shall be made of 1 part of cement, 3 parts of sand and 6 parts of broken stone or gravel. Broken stone for Class C concrete shall be the run of the crusher that will pass through a screen with circular openings 1 inch, 1-1/2 inch and 2 inches in diameter and be retained on a screen with circular openings 1/8 inch in diameter. Gravel for Class C concrete shall be as specified for Class A concrete. Broken stone, gravel and sand for Class C concrete shall in all respects comply with the requirements for similar materials for Class A concrete, except as to sizes as above specified.

55. RUBBLE CONCRETE.-

Rubble concrete shall consist of Class B concrete with large stones embedded therein. The embedded stones shall be hard, sound and durable, roughly cubical in shape and of such sizes as may be deemed suitable for the mass in

which they are to be used. They shall be laid on their largest beds and be so placed in the work that they will not be nearer than 9 inches to the bottom of a footing, to an expansion joint, to any surface or to each other. The stones after having been thoroughly cleaned and wetted shall be firmly bedded in the concrete. The joints shall then be filled and the stones covered with concrete to such a depth that the spacing specified will be obtained. The stones shall not be placed directly on any concrete which has acquired its initial set.

56. MEASURING INGREDIENTS.-

For the purpose of determining the proportions of the materials for concrete, each bag of cement will be considered as containing 1 cubic foot, and the other ingredients shall be measured by an approved method.

57. WATER.-

Only clean, fresh water shall be used for concrete.

58. MIXING.-

Unless permitted to be mixed by hand, concrete shall be mixed in approved mechanical batch mixers, so constructed and operated that the ingredients of the concrete may be accurately measured and will be thoroughly mixed. Enough water shall be added during the mixing to bring the concrete to the required consistency, which for concrete laid in place shall generally be such that the concrete

may be poured into place without causing the separation of the stones from the mortar. When concrete is mixed by hand, the broken stone or gravel shall be thoroughly wet before it is used. The cement and sand shall be mixed in the proper proportions dry until the mixture has an uniform color. It shall then be made into mortar of the desired consistency. The broken stone shall be added and the entire mass turned until each stone is entirely covered with mortar.

59. PLACING CONCRETE.-

Concrete shall be mixed only in such quantity as is required for the work in hand, and any that has set sufficiently to require re-tempering shall not be used. Any concrete in which the water has separated from the solid matter shall be satisfactorily remixed before being placed. The concrete shall be so deposited in the work as to prevent the separation of the stone from the mortar. It shall be deposited in as nearly a continuous operation as practicable and shall be worked, tamped, spaded or rammed with suitable tools to produce a dense and compact mass. When the operation of placing concrete is interrupted, the concrete in work shall, if required, be confined by suitable temporary forms or bulkheads. When concrete is to surround reinforcing rods, structural steel or wire netting, it shall be so deposited as to work closely round such material. When a comparatively dry concrete is used, it shall be deposited in horizontal layers not exceeding 6 inches in depth, and solidly tamped.

60. PRICES TO COVER--

The contract prices for the various classes of concrete shall cover the cost of all labor and materials required to furnish, place and remove all necessary forms and centers, and to make, furnish and protect the concrete as specified.

BRICK MASONRY.

61. QUALITY OF BRICKS.-

All bricks used in the work shall be sound and hard burned throughout and of uniform size and quality. If required, the bricks shall be culled immediately after they are brought on the work, and all bricks which are warped, cracked or of improper size, shape or quality shall be at once removed. The proportion of bats permitted will be determined according to the character and location of the work in which they are to be used. When bricks are used for lining inverts and in neat arch courses of sewers, they shall be specially selected and no bats shall be used except for closers.

62. VITRIFIED BRICKS.-

Where shown on the plan, vitrified bricks of approved size and quality shall be furnished and laid. After having been thoroughly dried and then immersed in water for 24 hours, they shall not absorb more than 4 per cent of their water weight.

63. HOW LAID:-

Bricks shall be satis-

factorily wet when being laid and each brick shall be laid in mortar so as to form full bed, and side joints in one operation. The joints shall not be wider than $3/8$ inch, except when the bricks are laid radically, in which case the narrowest part of the joint shall not exceed $1/4$ inch. The bricks shall be laid in a workmanlike manner, true to line, and wherever practicable the joints shall be carefully struck and pointed on the inside. Brickwork shall be laid with a satisfactory bond, and as it progresses shall be racked back in courses, unless otherwise permitted.

64. PROTECTION.-

All fresh brickwork shall be carefully protected from freezing and from the drying effects of the sun and wind, and if required, it shall be sprinkled with water at such intervals and for such a time as may be directed. Brickwork shall be protected from injuries of all sorts, and all portions which may become damaged or may be found defective shall be repaired, or if directed, removed and rebuilt. In freezing weather, bricks shall be heated when directed, sufficiently to remove all ice and frost.

65. MEASUREMENT.-

The amount of brick masonry to be paid for as such, will be all brick masonry built, as shown on the plan or as directed, except such brick masonry shown on the plan as parts of structures for which there are contract prices and the cost of which is herein-

after specified to be covered by the contract prices for such structures.

66. PRICE TO COVER.-

The contract price for brick masonry shall cover the cost of all labor and materials required to build and protect the same as specified.

STONE BALLAST.

67. QUALITY.-

Stone ballast shall be broken stone, clean, sound, hard and roughly cubical in shape and unless otherwise shown on the plan or directed, of sizes ranging from 1 inch to 4 inches. Cobbles, if satisfactory, may be used.

68. PRICE TO COVER.-

The contract price for stone ballast shall cover the cost of all labor and materials required to furnish and place the same as specified.

STEEL REINFORCEMENT BARS.

69. SHAPE.-

Steel bars for reinforcing concrete shall be of such shape as to afford an approved mechanical bond with the concrete and to insure intimate contact between the steel and concrete. Plain bars may be used only when shown on the plan.

70. SAMPLES.-

The Contractor shall indicate the type of bars proposed to be used and if required shall furnish samples thereof, and he is cautioned not to place the order for bars until the type has been approved.

71. SIZE:-

Each bar shall have a net cross-sectional area equivalent to that designated on the plan or required, or it shall be the commercial size of the approved type of bar having a net cross-sectional area next larger than that designated or required.

72. VARIATION IN WEIGHT.-

Reinforcement bars will be rejected if the actual weight varies more than 5 per cent from their theoretical weight, as shown by the manufacturer's tables. For weighing reinforcement bars, the Contractor shall, whenever required, provide an accurate scale of an approved type, with a capacity of not less than 500 pounds.

73. QUALITY.-

All steel for reinforcement bars shall be made by the open hearth process, and shall conform to the latest revised Standard Specifications for Steel Reinforcement Bars adopted by the American Society for Testing Materials. The chemical and physical properties of the steel shall be as follows:
Reinforcement bars shall be rolled from billets of new steel; they shall be

straight and free from seams, flaws, cracks and imperfections of all kinds.

74. TESTS AND INSPECTIONS.-

The provisions of sections relating to tests and inspections of structural steel shall also apply to tests and inspections of steel reinforcement bars. Test pieces 18 inches long may be cut from any of the bars delivered on the work, and the failure of any test piece to meet the specified requirements, or the failure of any bar when being tested or handled shall be deemed sufficient cause for the rejection of all steel from which the test piece or bar was made.

75. PROTECTION.-

Bars shall be protected at all times from mechanical injury and from the weather, and when placed in the work they shall be free from dirt, scale-rust, paint and oil. Bars which are to be imbedded in the concrete, but which remain exposed for some time after being placed in the work, shall, if directed, be immediately coated with a thin grout of equal parts of cement and sand.

76. CUTTING AND BENDING.-

Bars shall be bent into the shapes shown on the plan and in conformity with a proved templet. When bars are cut and bent on the work, the Contractor shall employ competent men and shall provide the necessary appliances for the purposes.

77. PLACING.-

All bars shall be as long as

can be conveniently used, accurately bent, placed, spaced and jointed as shown or directed, and they shall be securely held in place by approved devices until the concrete has been placed around them.

78. JOINTS.-

Where more than one bar is necessary to complete a required length, the joints shall be made by means of approved clamps which will develop the full strength of the bars by lapping the ends of the bars around each other in such a manner as to produce and maintain tension on the joint during construction or by lapping the ends of the bars, as directed, and wiring them together in an approved manner, or by lapping the ends of the bars for a distance of 21 times their normal diameters for deformed bars, and 40 times their nominal diameters for plain bars, and with a space not less than 2 inches between them. Joints in longitudinal bars shall be staggered as directed.

79. MEASUREMENT.-

The weight of steel reinforcement bars paid for as such, will be the weight computed from the lengths of and theoretical net sections of the steel reinforcement bars placed in the work in accordance with the plan or directions, except such steel reinforcement bars shown on the plan as part or parts of structures for which there are contract prices, and the cost of which is hereinafter specified to be covered by the contract prices for such structures. The weight paid for will not include the lengths of bars used for laps

for laps or wires, clamps and other devices used for spacing, jointing and securing the bars in place, or lugs, corrugations and irregularities which increase the weight of the bars above the weight of plain steel bars of the same net cross-sectional areas, the cost of which shall be covered by the price bid for steel reinforcement bars. In computing the weight of bars, 1 cubic foot of steel will be considered to weigh 489.6 pounds.

80. PRICE TO COVER.-

The concrete price for steel reinforcement bars shall cover the cost of all labor and materials required to furnish, clean, cut, bend, place, join, secure and protect the same, to furnish all test pieces and samples all as specified.

WIRE NETTING.

81. TYPE, QUALITY, etc.-

Wire netting of approved type and quality, and of the mesh and gage of wire shown on the plan, shall be furnished and placed where shown or directed. The netting shall be of steel wire. When placed in the work, wire netting shall be free from dirt, paint, oil and rust-scale. It shall be securely held in place by an approved method until the concrete has been placed around it.

82. PRICE TO COVER.-

The cost of all labor and materials required to furnish and place

wire netting as specified shall be covered by the contract price for the structure or class of work in connection with which it is used.

EXPANDED METAL.

83. TYPE, QUALITY, etc.-

Expanded metal of approved type and quality and of the weight and size of mesh shown on the plan, shall be furnished and placed where shown or directed. When placed in the work, it shall be free from dirt, scale, rust, paint and oil. It shall be placed in position with adjoining sheets lapped 1 mesh, and secured by an approved method until the concrete has been placed around it.

84. MEASUREMENT.-

The amount of expanded metal paid for as such will be all expanded metal placed in the work in accordance with the plan or directions, except such expanded metal shown on the plan as part or parts of structures for which there are contract prices for such structures, and which is hereinafter specified to be covered by the contract prices for such structures. The amount paid for will not include waste material out from sheets, nor the material used for laps, nor wires, clamps and other devices used in joining and securing the expanded metal in place, the cost of all of which shall be covered by the contract price for expanded metal.

85. PRICE TO COVER.-

The contract price for expanded metal shall cover the cost of all

labor and materials required to furnish, clean, cut, bend, place, join and secure the same as specified.

IRON CASTINGS.

86. QUALITY.-

Iron castings shall be of the best foundry pig iron, gray, tough and free from cold shuts, blow holes and other imperfections. (The weight shall be conspicuously painted by the manufacturer with white oil paint on each casting.) The castings shall be sound, true to form and thickness, clean and neatly finished. Where required, castings shall be thoroughly coated with coal tar pitch varnish.

87. PRICE TO COVER.-

The cost of all labor and materials required to furnish, place and coat the castings as specified, shall be covered by the contract price for the structure or class of work in connection with which they are used.

TIMBER.

88. QUALITY.-

All timber shall be Yellow Pine as specified and shall be sound and free from shakes, cracks, large or loose knots, and other defects impairing its strength and durability. It shall be squared to the required dimensions throughout its entire length.

89. PLACING.-

Timber shall be placed, as shown on the plan or directed and where necessary shall be firmly spiked or bolted with approved nails spikes, or bolts of such sizes and lengths and at such places

and in such numbers as shown on the plan, or as directed.

90. MEASUREMENT. -

The amount of timber to be paid for as such, will be all timber placed in the work in accordance with the plan or directions, except piles and timber sheeting and except such timber shown on the plan as part or parts of structures for which there are contract prices, and the cost of which is hereinafter specified to be covered by the contract prices for such structures. The amount paid for will not include timber used for forms, tamplets, centers, scaffolds, briuges (unless otherwise specified), fences, guard rails or other temporary structures, the cost of which shall be covered by all the contract prices for all the items for which there are contract prices. No deduction will be made in the measurement of timber on account of the spaces occupied by the piles.

91. PRICE TO COVER. -

The contract price for timber shall cover the cost of all labor and materials required to furnish, work, place and secure the same as specified.

TIMBER SHEETING.

92. QUALITY, PLACING, etc. -

Timber sheeting and the rangers and braces for the same shall be of a satisfactory quality or timber and of sufficient size and strength to adequately support the sides of the trenches and excavations. Sheetimg shall be driven in such a manner as to avoid cracking and splitting, and if required, for the proper prosecution of the work, shall be tongued and grooved.

93. WHEN PAID FOR.-

Timber sheeting will be paid for as such, only when left in place by written order of the Engineer. When sheeting is left in so much of it below the surface of the ground as may be directed, shall be cut off.

94. MEASUREMENT.-

The amount of timber sheeting to be paid for as such, will be all timber sheeting, rangers and braces left in place by written order, and will not include sheeting, rangers and braces left in place without such order, nor sheeting left in place because concrete is placed against it, nor that part of the sheeting that extended above the uppermost ranger after having been driven, the cost of all of which shall be covered by all the contract prices for all the items for which there are contract prices.

95. PRICE TO COVER.-

The contract price for timber shall cover the cost of all labor and materials to furnish, place and cut off the sheeting, rangers and braces as specified, and shall also cover the cost of all excavation necessary to place the same.

PILES.

96. QUALITY.-

Piles shall be of yellow pine as specified, sound and free from splits, snakes and other imperfections impairing their strength and durability. They shall be straight, taper uniformly from butt to point, and if so specified, shall be carked. Unless

otherwise shown on the plan, they shall conform to the following dimensions:

Length below cut-off	Min. Diam. at point	Max. Diam. at cut-off
Less than 20 feet	6	10
20 feet to 25 feet	6	11
26 feet to 35 feet	6	12
36 feet to 45 feet	6	13
46 feet and over	6	14

To determine the necessary length of piles to be used in the work, the Contractor may be required to drive test piles.

Each pile less than 60 feet long shall be in one piece; piles longer than 60 feet may be spliced in an approved manner. The small ends of piles shall be pointed, and if required, shall be snod with approved iron shoes.

97. HOW DRIVEN.-

Piles shall be driven without the use of a follower, unless specially permitted. Pile heads that become split or broomed shall be cut off and the driving continued. Any pile which splits, breaks or drives unsatisfactorily will not be paid for, and it shall be withdrawn or abandoned and another driven in place of it. After being driven, all piles shall be accurately cut off at the required elevation.

98. BEARING PILES.-

Bearing piles shall be driven vertically and shall be spaced as shown on the plan or as directed. They shall be driven to a satisfactory refusal by a hammer having a concave face and weighing not less than 2000 pounds. Refusal in general will be indicated by a penetration not exceeding 1 inch

per blow under the last 6 blows of a 2000-pound hammer falling 15 feet. If steam-hammer pile-drivers are used the piles shall be driven so that their bearing power shall not be less than that of piles driven as herein specified. When it is shown on the plan or specified that piles are to be driven to a certain required depth, they shall be driven by the use of a water jet, hammer or by any other approved method as may be necessary to reach this depth.

Where shown on the plan, brace, batter or spur piles shall be driven at the inclination shown or directed, and the tops shall be framed, bolted or strapped to adjoining piles or to each other as shown on the plan.

99. MEASUREMENT. -

The amount of piles to be paid for will be the total length below cut off or all piles remaining the work in accordance with the plan or directions and the total length of all piles used only as test piles. Piles driven for temporary use will not be paid for.

100. PRICE TO COVER. -

The contract price for piles shall cover the cost of all labor and materials required to furnish, drive and cut off the same as specified; of fastening the brace piles, and of furnishing and placing all shoes bands, bars, straps, bolts and other fastenings required.

VITRIFIED PIPE SEWERS.

101. VITRIFIED PIPE. -

Vitrified pipe sewers and

house connections shall be built of shale or clay hub and spigot pipes with deep and wide sockets. The pipes shall be manufactured at a suitable temperature, to secure a tough, vitreous material, without warps, cracks or other imperfections, and shall be fully and smoothly salt-glazed over the entire inner and outer surfaces, except that the inside of the hub and the outside of the spigot may be unglazed for two-thirds of the depth of the hub. On all other portions of the pipe, the glazing shall completely cover and form an integral part of the pipe body. If not left unglazed, the inside of the hub and the outside of the spigot shall be scored in three parallel lines extending completely around the circumference. When it is broken, vitrified pipe shall show dense and solid material without detrimental cracks or lamination; it shall be of such toughness that it can be worked with a chisel and hammer, and when struck with a hammer, it shall have a metallic ring.

102. IDENTIFICATION MARKS. -

Each pipe shall have clearly impressed on its outer surface, the name of the manufacturer and of the factory in which it was made.

103. SHAPE AND DIMENSIONS. -

The sizes of the pipes are designated by their interior diameters. Each pipe shall be a cylinder with a circular section, and shall have an uniform thickness.

The minimus lengths, thicknesses, depths of hubs and annular spaces for the respective sizes of vitrified pipes shall be as follows;

Size, inches.	Length feet.	Thickness inch
6	not less than 2	5/8
8	" " "	3/4
10	" " "	7/8
12	" " "	1
15	" " "	1 $\frac{1}{2}$
18	" " "	1 $\frac{1}{2}$
20	" " "	1 $\frac{2}{3}$
22	" " "	1 $\frac{5}{6}$

Depth of socket, inches.	Annular space. inch
2 $\frac{1}{2}$	5/8
2 $\frac{3}{4}$	5/8
2 $\frac{5}{8}$	5/8
3	5/8
3	5/8
3 $\frac{1}{4}$	5/8
3 $\frac{1}{2}$	5/8
3 $\frac{3}{4}$	5/8

104. CURVES, BENDS, etc.-

Where curved pipes are required, they shall be furnished in either one-eighth or one-quarter bands of their respective sizes. Curved pipes, bends, siphons and special pipe of the sizes and forms shown on the plan, shall be furnished and alid, and unless otherwise provided, they will be paid for at the contract prices corresponding to the sizes of vitrified pipe sewers.

105. SAMPLES FOR TESTING.-

Any or all of the following tests may be applied to samples selected by the Engineer from the pipe delivered on the work. For the purpose of making such

tests as may be required, the Contractor shall furnish and deliver, when directed, and at the place required, one length of pipe for each 200 feet pipe sewer to be laid.

106. CRUSHING TESTS.-

When supported at the bottom upon a knife edge one inch in width in such manner that an even bearing is provided throughout the whole length, exclusive of bell, and pressure is applied at the crown uniformly through a similar knife edge, the various sizes of pipe shall withstand the following pressures:

Diameter, inches.	Pressure, lbs. per lin.ft.	18	1250
6	900	18	140
8	900	20	1550
10	1000	22	1750
12	1050		

107. DROP WEIGHT TEST.-

When supported on a dry sand bed 2 inches deep, all pipe shall withstand without cracking, the impact from two blows of a cast iron ball weighing 8 pounds, falling 18 inches. Spurs shall resist without fracture the impact from two blows of such a ball falling 5 inches and striking on the extreme end of the hub or the spur.

108. ABSORPTION TEST.-

After having been thoroughly dried and then immersed in water for 2 hours, sample pieces of vitrified pipe about 10 square inches superficial area with all broken edges shall not absorb more than $5\frac{1}{2}$ of their weight of water.

109. FACTORY REJECTION.-

The entire product of any pipe factory may be rejected when, in the judgment of the Engineer, the methods of manufacture fail to guarantee uniform results, or where the materials used are such as produce inferior pipe, as indicated by repeated failure to comply with the tests herein specified.

110. HOW LAID.-

All pipes shall be laid with ends abutting and true to line and grade. The pipes shall be fitted together and matched so that when laid in the work, they will form a sewer with a smooth and uniform invert.

111. UNLESS otherwise shown on the plan, the joints shall be made as hereinafter specified in section 108.

112. PLAIN MORTAR JOINTS.-

Plain mortar joints shall be made in the following manner: Before a pipe is laid, the lower half of the hub of the preceding pipe shall be plastered on the inside with stiff mortar mixed 1 to 1, and of sufficient thickness to bring the inner bottoms of the abutting pipes, flush and even. After the pipe is laid, the remainder of the hub shall be thoroughly filled with similar mortar and the joint wiped inside and finished to a smooth bevel outside.

113. GASKET AND MORTAR JOINTS.-

Gasket and mortar joints shall be made in the following manner: A closely twisted hemp or co-

ödkum gasket of suitable diameter, in no case less than $\frac{1}{8}$ inch, and in one piece of sufficient length to pass around the pipe and lap at the top, shall be solidly rammed into the annular space between the pipes with a suitable calking tool. Before being placed, the gasket shall be saturated with neat cement grout. The remainder of the space shall then be completely filled with plastic mortar mixed 1 to 1 and the joint wiped inside and finished to a smooth bevel outside.

114. JOINTS FOR SANITARY SEWERS AND BITUMINOUS COMPOUND FOR SAME.-

Joints of sanitary pipe sewers below the normal water table shall be made with a compound approved by the Engineer. The compound shall preferably have a bituminous base, shall adhere firmly to the glazed surfaces of the pipes, shall melt and run freely at a temperature as low as 250° F. and when set shall be sufficiently elastic to permit of a slight movement of the pipes without injury to the joints or breaking the adhesion or the compound to the pipes. The compound shall not deteriorate when submerged in fresh or salt water or normal domestic sewage. It shall show no deterioration of any kind when immersed for a period of five days in an 1% solution of hydrochloric acid or 5% solution of caustic potash.

All sanitary sewers below the normal water table shall be laid in concrete cradles as shown on the plans; the joints shall be carefully centered and calked as specified in article 112. After a joint is properly calked; in a suitable runner shall be placed, and the compound heated to a temperature of approximately 400° F., shall be poured into it in such a

manner that the annular space shall be completely filled to within $\frac{1}{2}$ inch of the outer rim of the bell of the pipe.

After the joints are run and the concrete cradle is placed, those portions of the joints not imbedded in the cradle, shall be encased in cement mortar, which shall extend at least 2 inches from the face and outside of the bell. The cement mortar shall be mixed in the proportions of 1 part of cement to 1 of sand.

115. INSPECTION OF JOINTS.-

Unless otherwise permitted, at least four finished joints shall be left exposed for inspection throughout the working day, and the necessary staging for the protection of the exposed setters and for the handling of excavated material shall be provided. A suitable ladder affording easy access for such inspection shall be furnished at every trench, open for the proposed sewer. The joints on the inside of all pipe sewers larger than 12 inches in diameter, shall be carefully filled with mortar and wiped smooth and flush with the surface of the pipe.

116. SUB-GRADE TO BE TESTED.-

No pipe or cradle therefore, shall be laid or placed until the sub-grade of the trench shall have been tested and found correct.

117. SEWER TO BE KEPT CLEAN.-

The interior of the sewer shall, as the work progresses, be cleared of all dirt, cement and super-

illuous materials of every description.

118. BACKFILLING. -

Immediately after the sewer is laid, the trench shall be backfilled as provided in sections 31, 32, 34, 35, 36, 37, 38, 39. No walking on or working upon the completed sewer (except as may be necessary in tamping the backfilling) will be permitted until the trench has been backfilled to a height of at least 2 feet over the top of the sewer.

119. THE exposed ends of pipe sewers shall be provided with approved temporary covers fitted to the pipe so as to exclude earth and other materials.

120. BRANCH PIPES.-

Branch pipes and connection pipes shall be of the same quality and dimensions and laid in the same manner as specified for pipe sewers. Dead ends of pipes shall be closed with oak heads or brick masonry 8 inches in thickness.

121. PIPES CUT TO FIT MASONRY.-

The ends of pipes which enter masonry shall be neatly cut to fit the face of the masonry. When directed, such cutting shall be done before the pipes are built in.

122. MEASUREMENT.-

The length of pipe sewers to be paid for will be determined by measurements along their invert lines, and no deductions will be made on account

or openings at manholes.

123. PRICES TO COVER.-

The contract prices for pipe sewers shall cover the cost of all necessary excavation (except rock when there is a contract price for rock excavation); of all sand, gravel, broken stone or concrete oradles required; of the making of all joints as specified; of all necessary trimming, fitting and building into masonry; of all bulkheads, in the ends of sewers to which connection is made by the sewers in the contract; and of all labor and materials required to furnish and lay the sewers complete in place as shown on the plan and as specified.

CEMENT CONCRETE PIPE SEWERS WITH REINFORCEMENT.

124. SHAPE AND DIMENSION.-

Reinforced cement concrete pipes used in the construction of sewers shall be circular in section without flat base. Variations not greater than one-half ($\frac{1}{2}$) percent from such dimensions will be permitted.

125. ENDS OF PIPES.-

The ends of such pipes shall be molded with hubs and swigots or with any other shapes which are satisfactory to the Engineer, and which will permit the making of tight, smooth and permanent joints. The shapes of the pipe ends shall be such as to require and permit the making and finishing of the joints both on the inside and outside of the sewer.

126. TYPE OF REINFORCEMENT.-

The minimum

lengths, thicknesses and depths of flues for the respective sizes of reinforced concrete pipes, shall be as follows:

Size inches.	Lengths, feet.	Thickness, inches
24	4	3
30	4	3 $\frac{1}{2}$
36	4	4
42	4	4 $\frac{1}{2}$
48	4	5
54	4	5 $\frac{1}{2}$
60	4	6
66	4	6 $\frac{1}{2}$
72	4	7
78	4	8
84	4	8

127. TYPE OF REINFORCEMENT. -

The steel used for reinforcement of cement concrete pipe shall conform to the requirements for such material specified in section number 73.

- It shall either be expanded metal, rods or wire mesh, equal in quality and design to that manufactured by the American Steel and Wire Company.
- Where reinforcement in pipes is exposed, it shall be thoroughly painted with cement grout so as to prevent deterioration by exposure to the weather, unless the reinforcement is galvanized.

128. REINFORCEMENT FOR CIRCULAR PIPES. -

In all sizes of circular reinforced concrete pipe from 24 inches to 48 inches in diameter, inclusive, reinforcement shall be placed at distances varying from 1 inch to 1 $\frac{1}{2}$ inches from the inner surfaces according to diameter of pipes, as shown on the plan.

- Either one or two lines of reinforcement

may be used in the above sizes of pipes.

b. In all circular pipes whose diameters exceed 48 inches, two lines of reinforcement shall be used, unless otherwise shown on the plan.

c. The inner line of reinforcement shall be placed 2 inches from the inner surface. The outer line of reinforcement shall be placed $1 \frac{3}{4}$ inches from the outer surfaces.

129. SAMPLES FOR TESTING.-

Any or all of the following tests may be applied to samples selected by the Engineer from the pipe delivered on the work. For the purpose of making such tests as may be required, the Contractor shall furnish and deliver, when directed, and at the place required, 3 lengths of each size of pipes used in the work.

130. CRUSHING TESTS.-

When tested in the manner described in section number 106, the various sizes of pipes between 24 inch and 42 inch in diameter, inclusive, shall withstand, without collapse, the following pressure. When supported upon a saddle which extends the full length of the pipe exclusive of the belt and whose upper surface fits accurately the outer curved surface of the pipe, and whose width is equal to an arc of 100, in such a manner that an even bearing is provided throughout the whole length, and pressure is applied to the crown uniformly through a knife edge 1 inch in width, the various sizes of pipes with diameters greater than 42 inches shall withstand without collapse,

the following pressures;

Diameter, inches.	Pressure, lbs. per lin. ft.	Diam. in.	Pres. foot
24	1950	60	5000
30	2350	66	5500
36	2800	72	6000
42	3200	78	6500
48	3800	84	7000
54	4400		

131. REINFORCED concrete pipe in which the reinforcement is not placed symmetrically about the circumference of the shell in which only one concentric line of reinforcement is used, shall be tested in such manner as to develop the same bending moments at the extremities of the vertical and horizontal diameters, as will be developed at the crown by the tests specified above.

132. SPURS AND BRANCHES.-

Reinforced cement concrete pipes having openings to receive spur and branch connections shall be furnished and laid at such points as the engineer may designate and as called for by the plan. The openings in pipes shall be made in accordance with a plan approved by the Chief Engineer, and the openings shall be such that connection may be made with the sewer in as effective a manner as is possible with pipes with molded spur connections.

BASIN CONNECTIONS.

133. THE connections between receiving basins or inlet basins and sewer or manholes shall be 12-inch vitrified pipe, unless otherwise shown on the plan. The pipes shall be of the same quality and dimensions and laid in the same manner as hereinbefore specified for vitrified pipe sewers.

134. MEASUREMENT.-

The lengths of basin connections to be paid for will be determined by measurements along their invert.

135. PRICE TO COVER.-

The contract price for basin connections shall cover the cost of all necessary excavation (except rock, when there is a contract price for rock excavation); of all sand, gravel, broken stone, or concrete cradles required; of all embankments required to furnish and lay the basin connections complete in place, as specified.

PIPE DRAINS.

136. PIPE drains shall be built of vitrified or cement concrete pipe of the same quality and dimensions and laid in the same manner as hereinbefore specified for pipe sewers.

137. MEASUREMENT.-

The lengths of pipe drains to be paid for will be determined by measurements along their invert.

138. PRICES TO COVER.-

The contract prices for pipe drains shall cover the cost of all necessary excavations (except rock, when there is a contract price for rock excavation); of all necessary trimming, fitting and building into masonry; of all backfilling; of all embankments required; and of all labor and materials required to furnish and lay the drains complete in place, as specified.

SPURS FOR HOUSE CONNECTIONS.

139. SPURS for house connections shall be vitrified or cement concrete pipe 6 inches in diameter, equal in quality and dimensions to that specified for pipe sewers.

140. IN BRICK AND CONCRETE SEWERS.-

In brick and concrete sewers, spurs shall be built in as shown on the plan or as directed. They shall be hub-and-spigot pipes with the spigot and moulded or cut to fit flush with the inner surface of the sewer, and of sufficient length to reach the exterior of the sewer.

141. IN PIPE SEWERS.-

Pipes having 6-inch spurs with hubs moulded thereon, shall be furnished and laid in pipe sewers where shown on the plan or directed. The cost of such pipes shall be included in the contract prices for pipe sewers.

142. COVERS.-

The ends of all spurs not connected with drains shall be closed with a roved covers of the same material as the pipes. If required, such covers shall be cemented in place, and when directed the covers shall be so cemented before the pipes are lowered into the trench.

143. PRICE TO COVER.-

The cost of spurs and all labor and materials required to furnish and place the same as specified and furnishing and cementing the covers for the same, shall be included in the contract price of the sewers to which they connect. They shall be furnished

and laid as above specified without extra cost to the city.

DRAINS FOR HOUSE CONNECTIONS.

144. WHERE shown on the plan or where directed, drains for house connections shall be built from the spurs in such manner and for such distance as may be shown or directed.

145. DEPTH AT CURB.-

Generally house-connection drains shall be laid with such a gradient as to secure a depth at the curb line of $9\frac{1}{2}$ feet or at a gradient of $\frac{1}{4}$ inch per foot. Where this is not possible or advisable, the depth at the curb line shall be as shown on the plan.

146. MATERIAL.-

Unless otherwise shown on the plan, drains for house-connections shall be of pipe of the quality and dimensions specified for pipe sewers. The ends of drains shall be closed with approved covers of the same material as the pipe.

147. HOW LAID.-

All the requirements, as hereinbefore specified, relating to excavation, laying and backfilling of pipe sewers shall apply, as far as they are applicable, to drains for house connections.

148. MEASUREMENTS.--

The lengths of pipe drains for house connections to be paid for will be determined by measurement along their invert. They shall be measured from the line of the spur attached to the drain sewer or rafter.

149. PRICE TO COVER.-

The contract price for drains for house connections shall cover the cost of all necessary excavation (except rock, when there is a contract price for rock excavation); the cost of all backfilling; the cost of all covers, bends and specials required; of all sand, gravel, broken stone or concrete cradles; and the cost of all labor and materials required to furnish and lay the drains for house connections complete in place, as specified and as shown on the plan.

MANHOLES.

150. THE masonry or concrete for manholes shall be built to within inches of the established grade of the street or to within inches of the existing surface of the ground, as directed. When not built up to within inches of the established grade of the street, the masonry or concrete shall, if directed, be covered with stone slats not less than 3 inches thick or with an approved reinforced concrete slab to support the head.

151. BRICK MANHOLES.-

Brick manholes shall be formed by means of templets placed at top and bottom with not less than 8 lines drawn between them if directed by the Engineer, and shall be smoothly and evenly plastered on the outside with a layer of mortar $\frac{1}{2}$ inch thick.

152. STEPS.-

Galvanized wrought-iron steps or the size and shape shown on the plan shall be firmly built into the manholes at vertical intervals of about 16 inches.

153. HEAD AND COVER.-

Manhole heads and covers shall be of cast iron, and unless otherwise shown on the plan, each head, exclusive of cover, shall weigh not less than 475 pounds and each cover shall weigh not less than 150 pounds. The weight of each head and cover shall be conspicuously painted thereon by the manufacturer with white oil paint. The head shall be set on the masonry or concrete in a full bed of stiff mortar.

154. DUST PANS, etc., -

Where shown on the plan, dust pans and protection gratings or the materials, forms and dimensions shown, shall be furnished and fitted in the manholes.

155. PRICE TO COVER.-

The contract price for manholes shall cover the cost of all necessary excavation (except rock, when there is a contract price for rock excavation); of all backfilling; of all plastering; of all stone and concrete steps; of all steps; of heads and covers; of dust pans and protection gratings, when required; and of all labor and materials required to construct the same complete, in place, as shown on the plan, and specified.

STORM WATER INLETS.

156. STORM-WATER inlets and the beds and covers thereto shall be of the materials, forms and dimension shown on the plan. If required, the mouth of inlets shall be closed with bulkheads of brick masonry and such bulkheads shall be removed when erected.

157. PRICE TO COVER.-

The contract price for inlets shall cover the cost of all necessary excavation (except rock, when there is a contract price for rock excavation); of all backfilling; of connections with sewers, or basins; of the temporary brick bulkheads in the mouths of the inlets when required; and of all labor and materials required to construct the inlets complete in place, as shown on the plan and specified.

RESTORATION OF SURFACE AND CLEANING UP.

158. RESTORATION OF UNPAVED ROADWAYS,
SIDEWALKS, etc., -

At such time as may be directed, all unpaved roadways, gutters, and sidewalks affected by the work done under this contract shall be restored by the Contractor to the same condition in which they were at the time of the opening or bid for this contract.

159. PAVERMENTS, etc., RESTORED BY CITY.-

Unless otherwise required by the plan, all roadway and sidewalk pavements, crosswalks, curbs, etc., along the line of the work, (except those under guarantee for maintenance by the paving Contractor), which are removed, destroyed, lost or injured on account of, or during the construction of the work under this contract, or which are injured by traffic on account of any act or omission on the part of the Contractor, his agents, servants or employees, in the prosecution of the work, will be restored and adjusted by the city

at the expense of the Contractor. For this purpose, before the completion of the contract, and when directed, the Contractor shall pay to the city a sum of money sufficient to cover the cost of the work to be done being determined by the Engineer, and the cost being computed at the following prices:

Granite block with concrete foundation, tar and gravel (or cement grout) joints

.....per sq. yd.

Granite block pavement, with sand foundation

Medina block pavement, with concrete foundation (routed joints)

Brick pavement, with concrete foundation

Brick pavement, with sand foundation

Belgian block pavement

Cobblestone pavement

Macadam pavement

Iron slag pavement

Wood block pavement

Asphalt block pavement over 10 yards

Asphalt block pavement under 10 yards

Sheet asphalt pavement, concrete foundation over 10 yards.

Sheet asphalt pavement, concrete foundation, under 10 yards.

Asphalt pavement without concrete foundation, over 10 yards.

Asphalt pavement without concrete foundation under 10 yards.

Cement sidewalk relaidper sq. ft.

New Flagging

Flagging relaid

Curostone reset, concrete foundation ...per square ft.

Curostone reset, sand foundation

New curostone furnished and set, sand foundation

New curostone furnished and set, concrete foundation

Brickstone reset, sand foundationper sq. ft.

Bridgestone reset, concrete foundation
New bridgestone furnished and set, sand foundation
New bridgestone furnished and set, concrete foundation

160. PAVEMENTS, etc., RESTORED BY CONTRACTOR.-
If required by the plan, roadway and sidewalk, pavements, cross-walks, curbs, etc., except those under guarantee for maintenance, shall be satisfactorily restored and adjusted by the Contractor at such times as may be directed. Sidewalk pavements shall be restored in whole flags, squares or sections which shall correspond in quality and appearance with the original or adjoining flags, squares or sections. All work and materials used in such restoration and adjustment shall conform in all respects to the standard specifications now in use by the city for similar work and materials.

161. PAVEMENTS, etc., UNDER GUARANTEE.-

All pavements, sidewalks, cross-walks, curbs, etc., existing at the time of the opening of the bids for this contract, and under guarantee for maintenance, shall be restored and adjusted by the parties responsible under such guarantee, and at the expense of the Contractor. If not so restored and adjusted during the progress of the work, the Contractor shall when directed, pay to the city, before completion of the contract, a sum of money sufficient to cover the cost of having the same restored and adjusted by the parties responsible under such guarantee, and at the charges for the restoration of the same as set forth in their contract relating thereto. Such shall be accompanied by certificates

from the responsible for the maintenance of the pavements, sidewalks, cross-walks, curbs, etc., to the effect that such sum will be accepted by them as covering the entire quantity of pavement, etc. to be restored and adjusted.

162. TEMPORARY RESTORATION.-

At such times as may be directed, roadway and sidewalk pavements, cross-walks, curbs, etc., which may have been removed, whether under guarantee or not, shall be temporarily restored by the Contractor to the satisfaction of the Engineer.

163. CHANGE OF PAVEMENT, etc.,-

When the kinds of pavements, sidewalks, cross-walks, curbs, etc., in any street affected by this contract, are changed after the bids are opened and before work is commenced, the Contractor will not be required to make permanent restoration of the new pavement, sidewalks, cross-walks, curbs, etc., disturbed, but a sum of money sufficient to pay the cost of replacing the kinds of pavements, sidewalks, cross-walks, curbs, etc., which were there at the time of the opening of the bids for this contract, will be deducted from the amount which would have been payable to the Contractor upon the completion of the contract, had the character of pavements, etc., not been changed, and such cost will be computed at the prices stated in section 109.

164. WHEN NEW PAVEMENT IS LAID.-

If pavement, sidewalks, cross-walks, curbs, etc., are laid where none existed at the time the bids for

this contract were opened, the Contractor shall excavate and remove such portions of the pavements, sidewalks, cross-walks, curbs, etc., and their foundations as may be necessary for the prosecution of the work, but he will not be required to make a permanent restoration of them.

165. TRENCHES FLOODED.-

Beflore laying any pavements, sidewalks, cross-walks, curbs, etc., the trenches shall, if required, be flooded with water, as directed, and all resulting holes or depressions shall be filled and tamped solid.

166. UNNECESSARY CROSS GUTTERS.-

All cross gutters rendered unnecessary by the work under this contract shall be removed and the entire street intersection or so much thereof as may be necessary shall be re-graded and repaved as herein specified.

167. CLEANING UP.-

At such times as may be directed, the Contractor shall remove from the streets all materials which were placed thereon by him as a consequence of performing this work, and which are not required by the contract to be left as part of the finished work. The entire work and portions of the street affected thereby shall be left in a satisfactory condition. The sidewalks and cross-walks shall be swept clean of all material which may have accumulated under this contract, and if required, they shall be sprinkled with water during the sweeping.

168. PRICES TO COVER.-

The cost of all the

labor required to be done and all materials required to be furnished in the performance of all of the work specified in sections..., inclusive, shall be covered by all the contract prices for all the items for which there are contract prices.

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15
31

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L.

SEWER

MANHOLE

DROP MANHOLE

INLET MANHOLE

LEGEND

SEWER _____

MANHOLE _____ O

DROP MANHOLE _____ 1

INLET MANHOLE _____ Q

2990.

2980.

2970.

2960.

YELLOWSTONE
RIVER

OUTFALL

①

2990.

ASH ST

2980.

2970.

2960.

YELLOWSTONE
RIVER

60"

60"

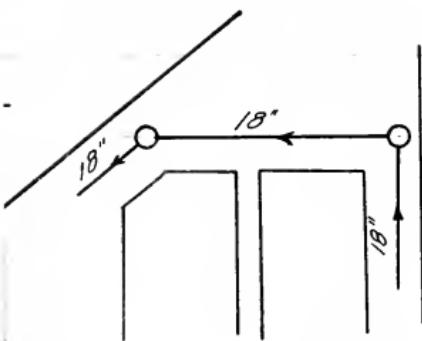
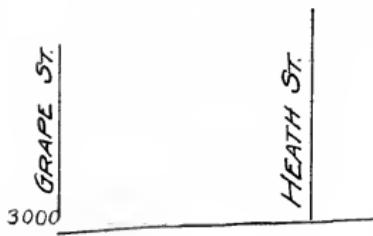
60"

60"

60"

FIRST ST. SOUTH

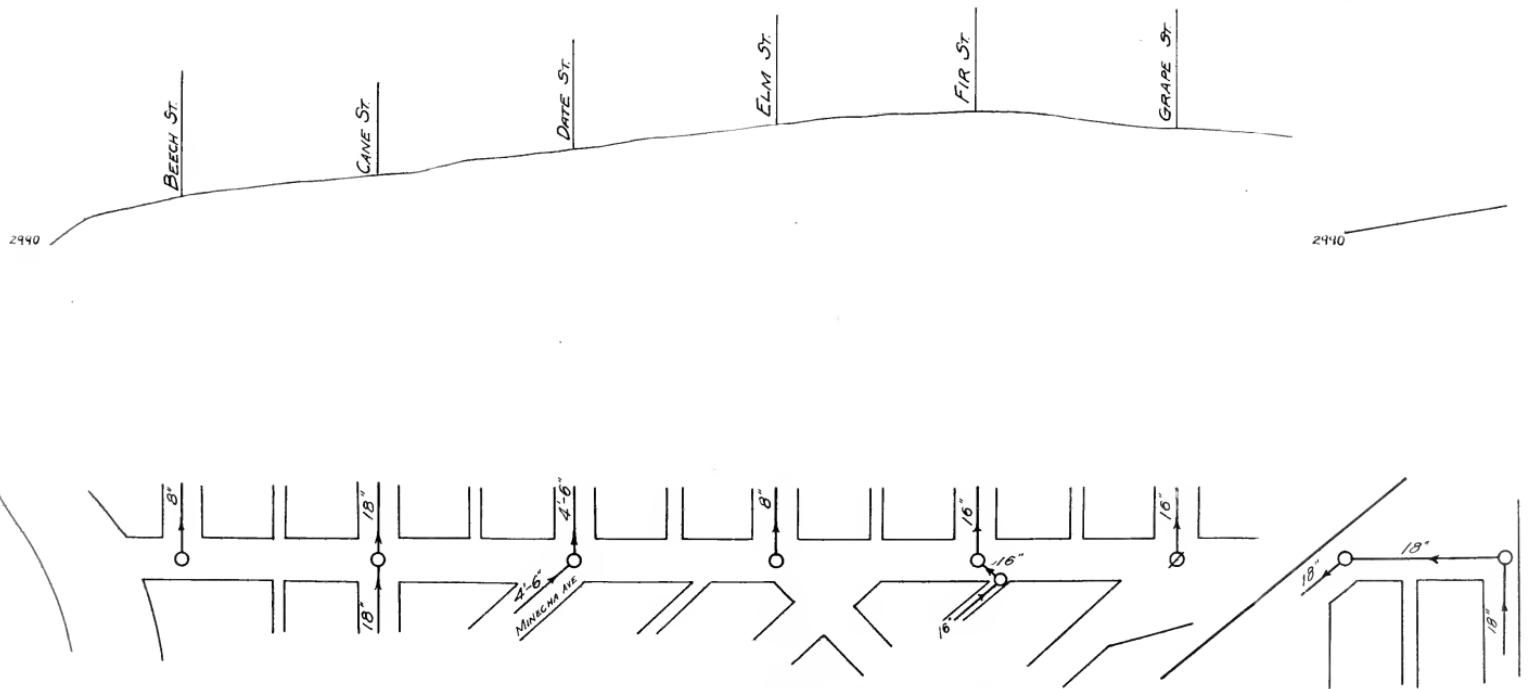
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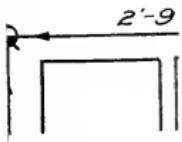


FIRST ST NORTH

FIRST ST SOUTH

(2)





THIRD STREET NORTH

Asst. St.
BEECH ST.

CANE ST.

BATE ST.

ELLEN ST.

FIR ST.

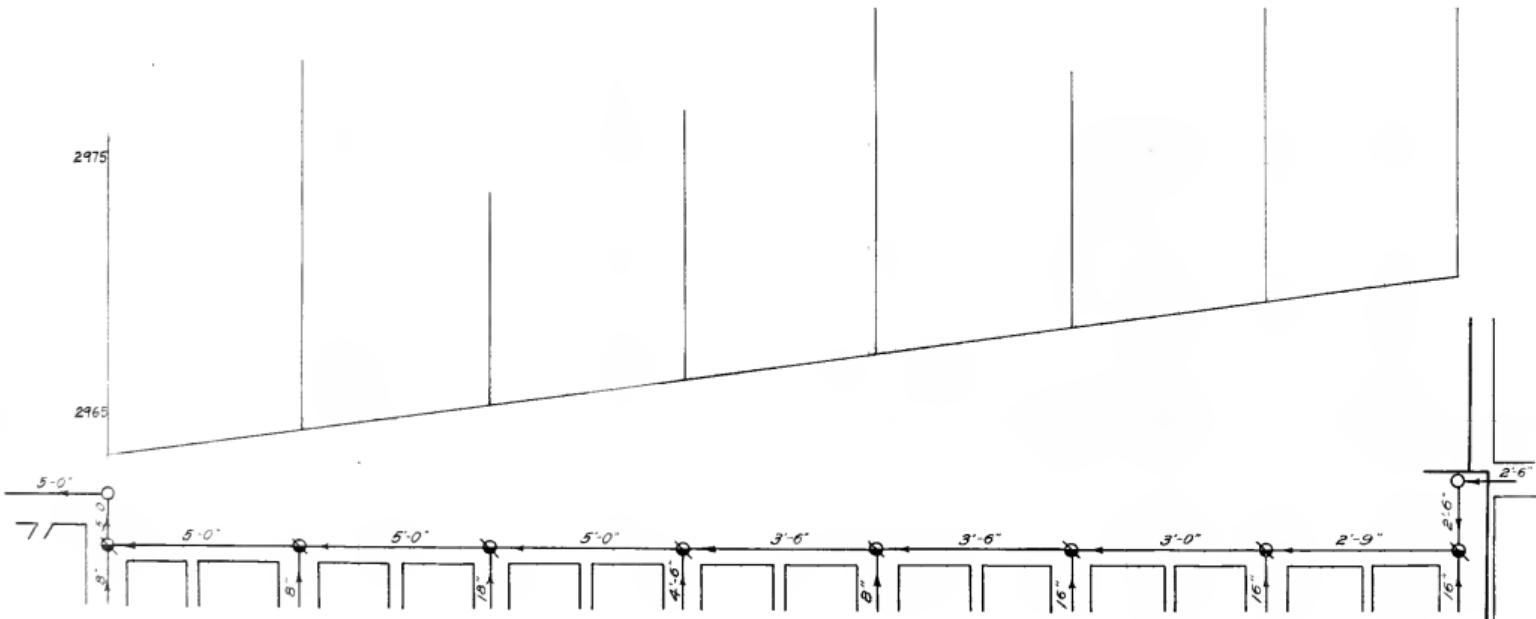
GRAPe ST.

HEATH ST.

2985

2975

2965



THIRD STREET NORTH

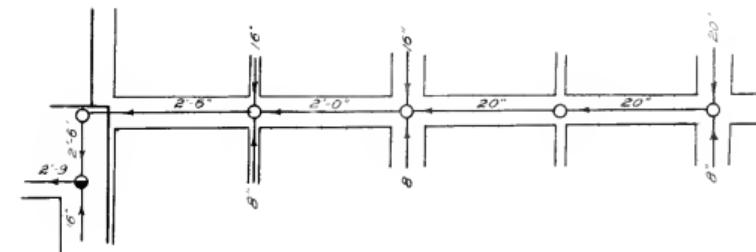
HEATH ST.

IVY ST.

JULIE ST. (3)

2985

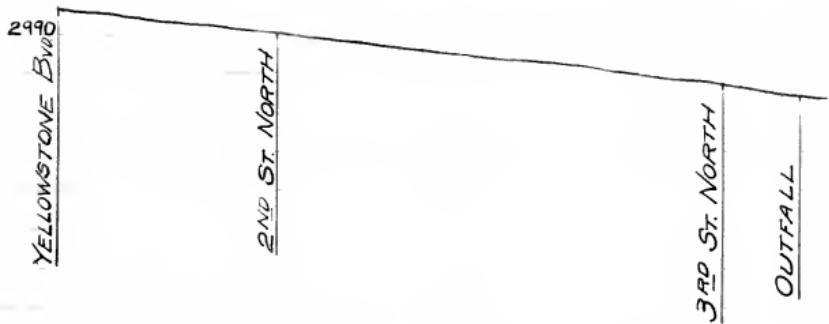
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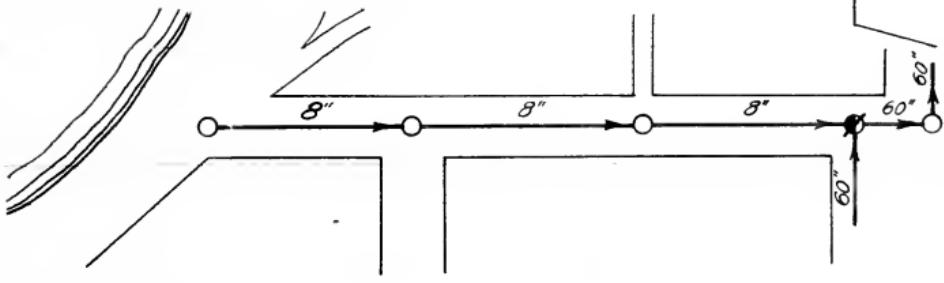
ASH ST.

(4)



2980

2970

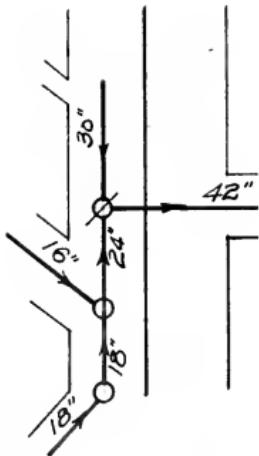




2995

50. CANAL DRIVE
MAIN CANAL
No. CANAL DRIVE

2985



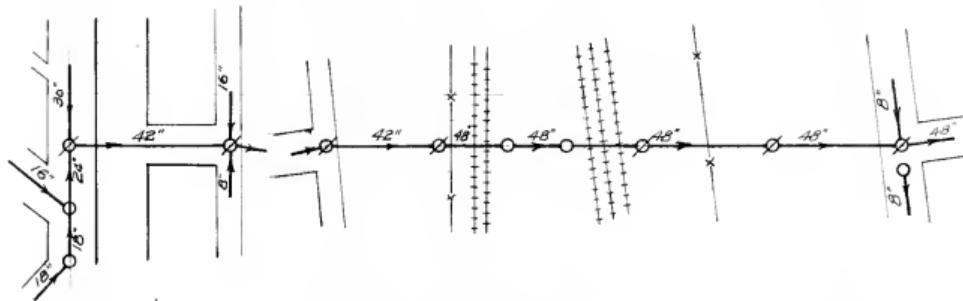


CANAL & R.R. CROSSING (MAIN SEWER)

⑤

2995 SO. CANAL DRIVE
MAIN CANAL
No. CANAL DRIVE
UNNAMED
CHANGE IN ALIGNMENT
UNNAMED
C.B. & Q.R.R.
N.O. PAC. R.R.
NORTHERN AVE.

2985





R.R.FENCE

2990

/

2980





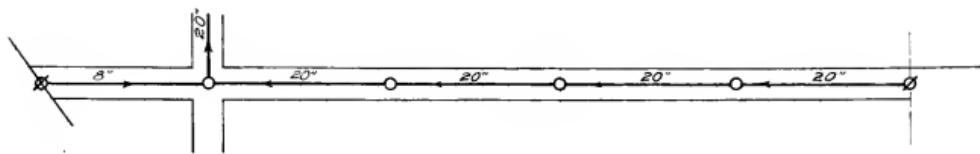
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JUTE ST.



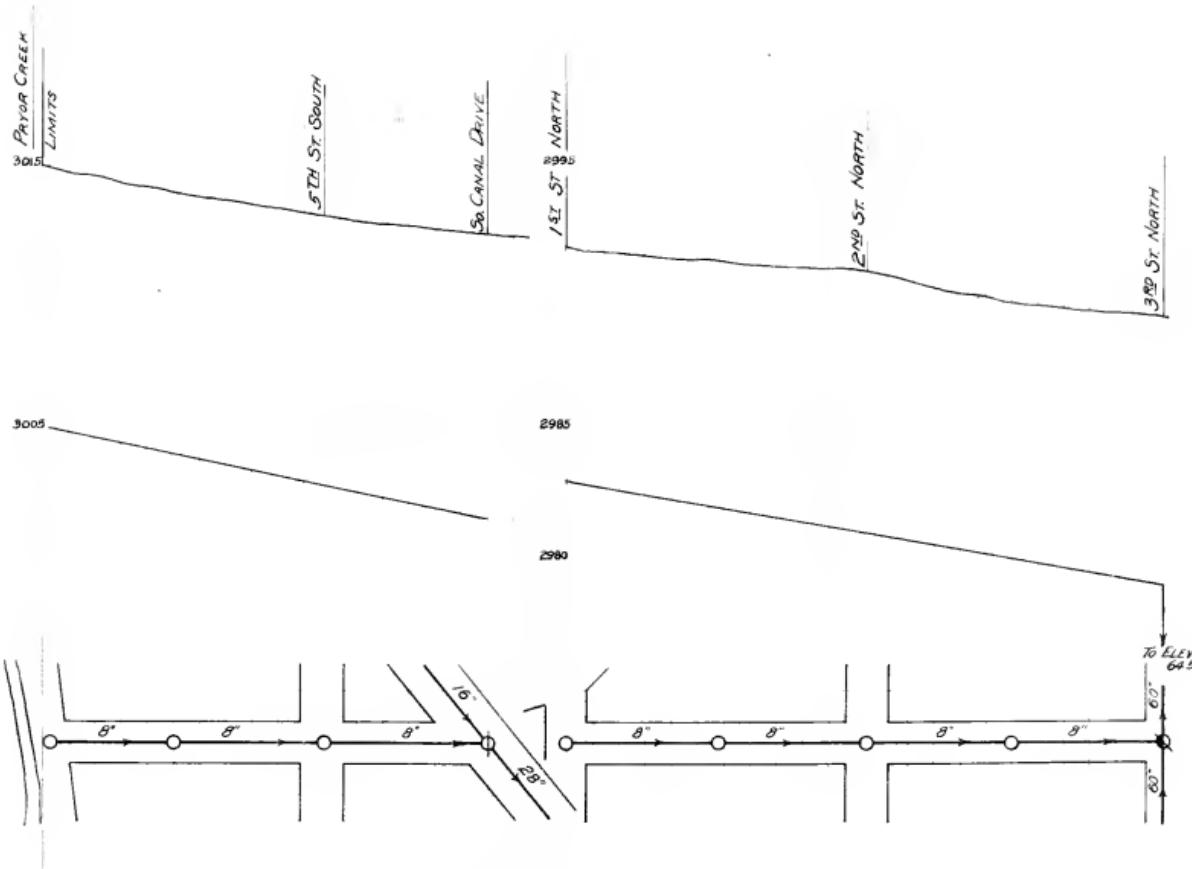
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2970



BEECH ST.

(7)



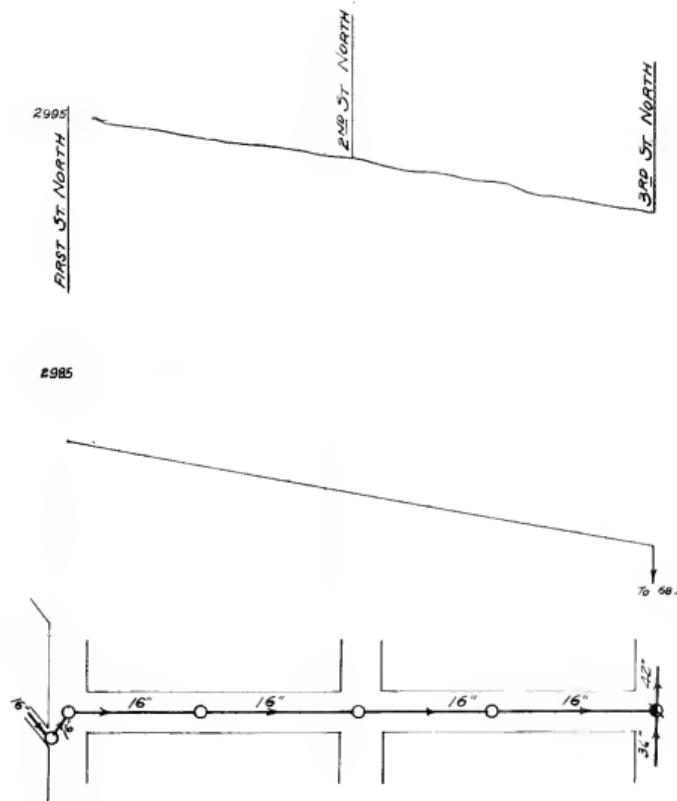
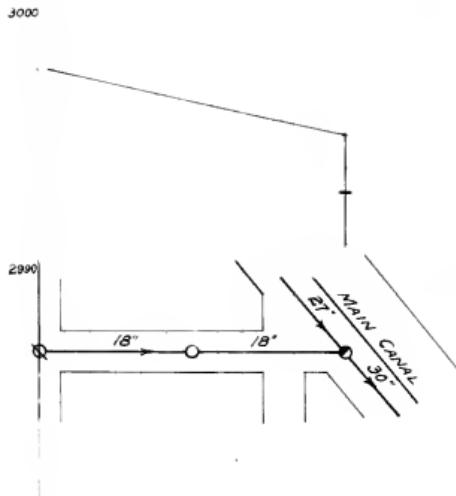
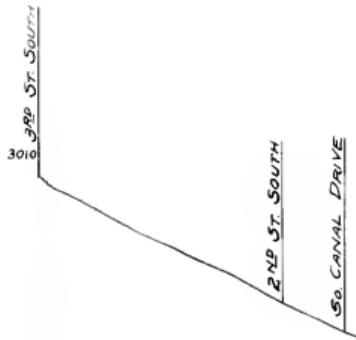






FIR STREET

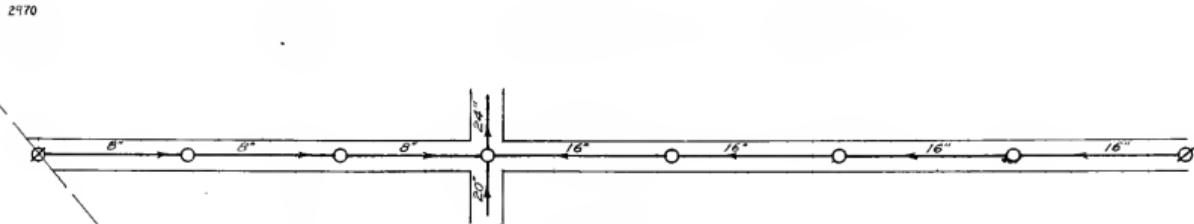
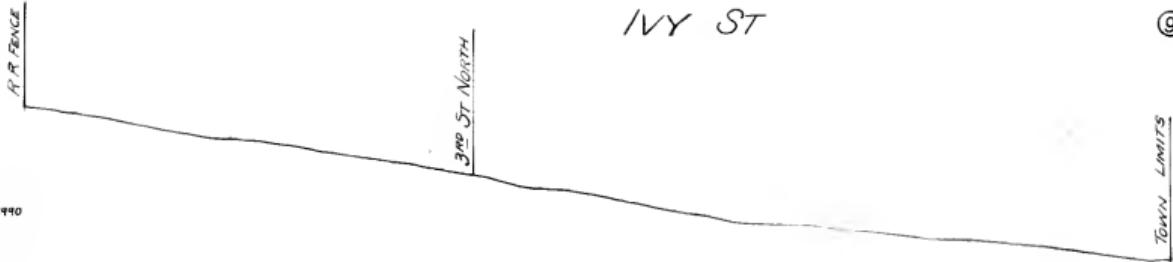
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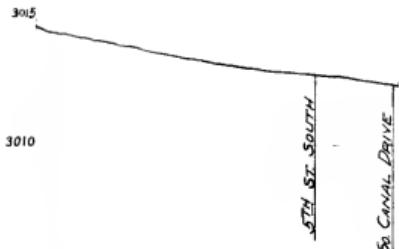




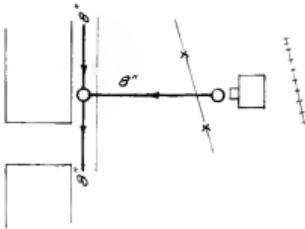
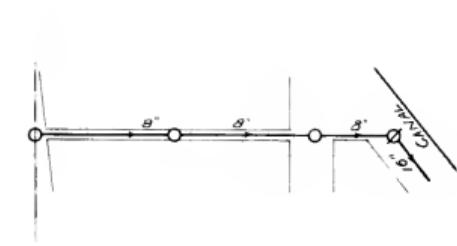




ALLEY W of BEECH St



LATERAL FROM R.R. DEPOT (10)



(11)

3RD SOUTH

3005

3RD ST. NORTH

2995

TO ELEV
69.5

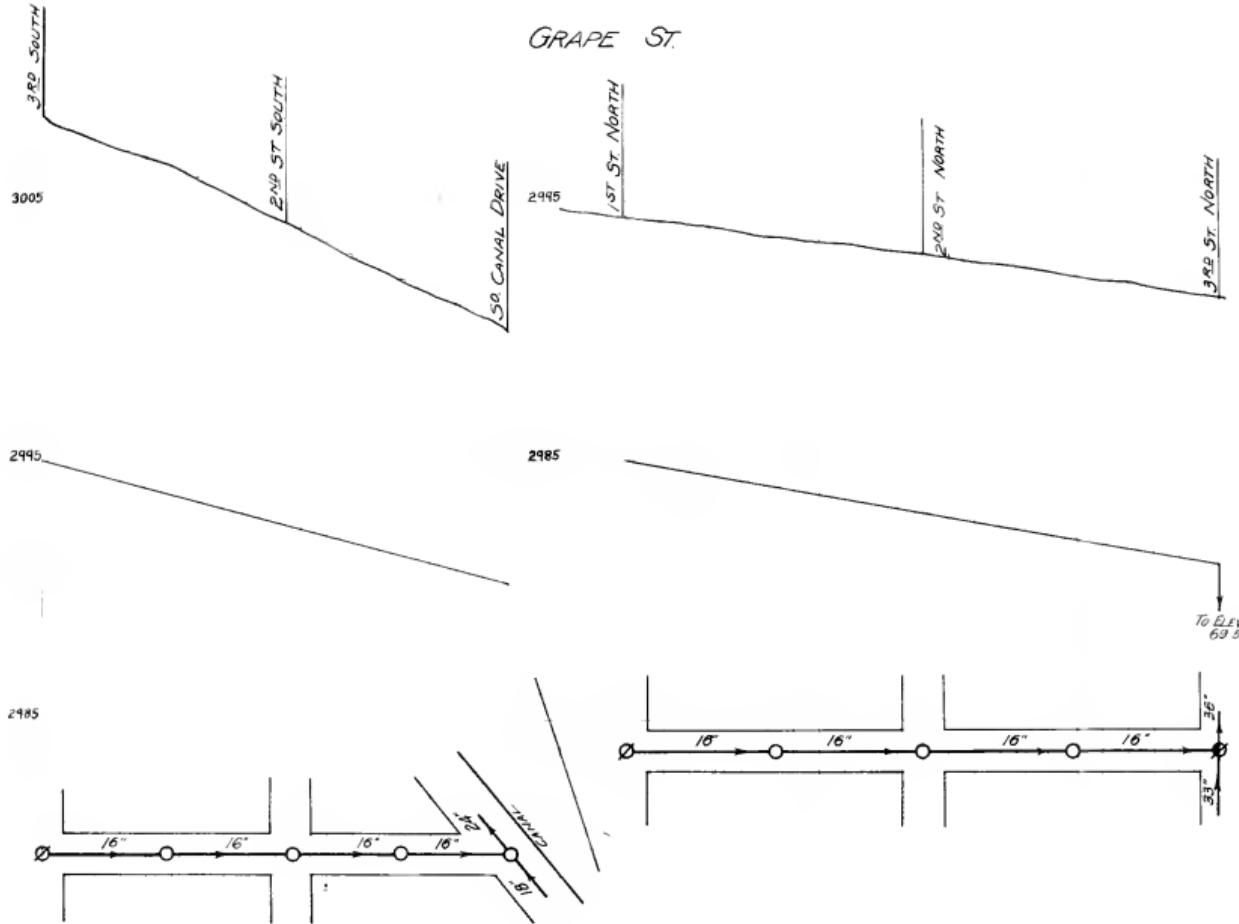
2985

16"

36"
33"

Q

GRAPE ST.



R.R. LIMITS

(12)

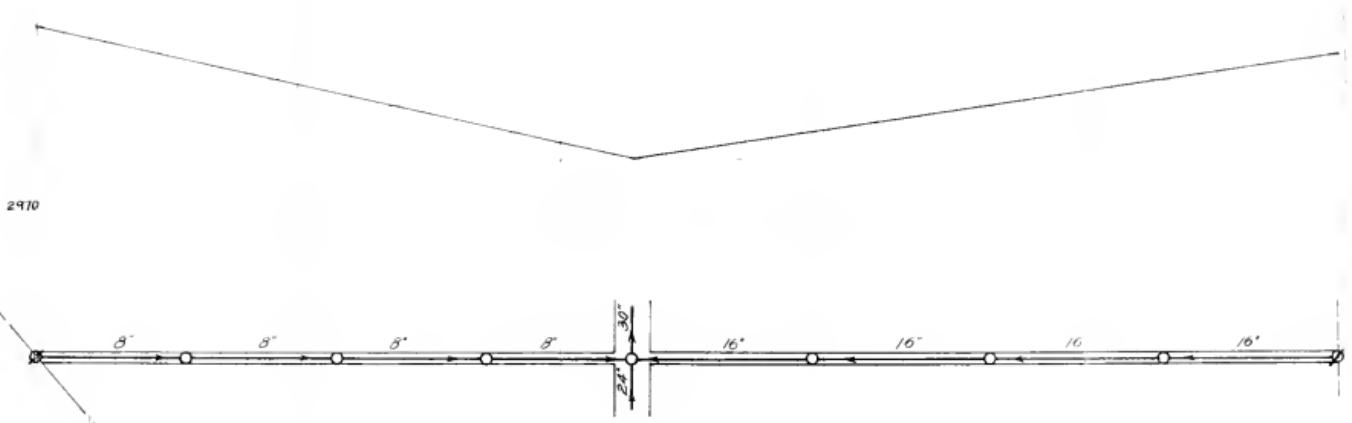
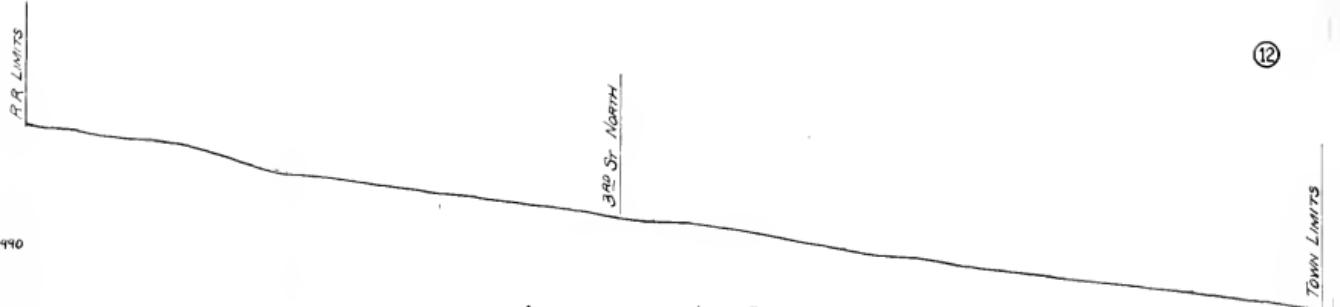
2990

TOWN LIMITS

2980

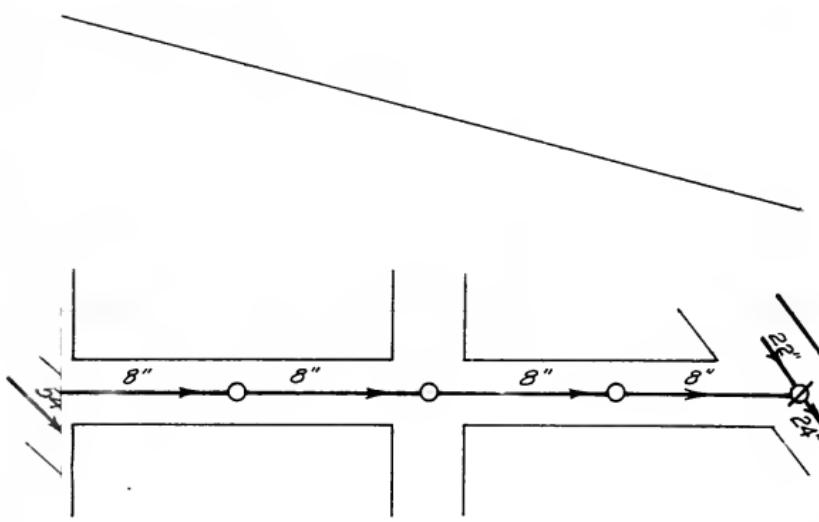
2970

/6"





DATE ST.

4TH ST. SOUTHSO. CANAL DRIVE



1ST ST. NORTH

DATE ST.

O

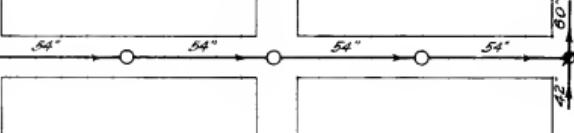
2ND ST. NORTH

3RD ST. NORTH

2985

2975

45°



RAYOR GREEN

3015

LIMITS

DATE ST.

⑬

5TH ST. SOUTH

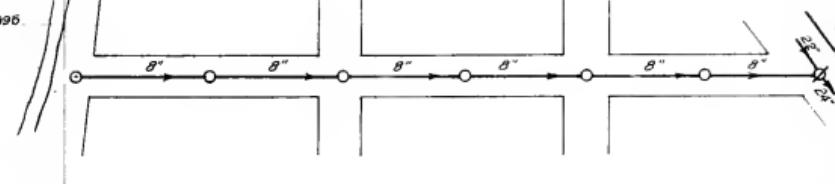
4TH ST. SOUTH

CANAL DRIVE

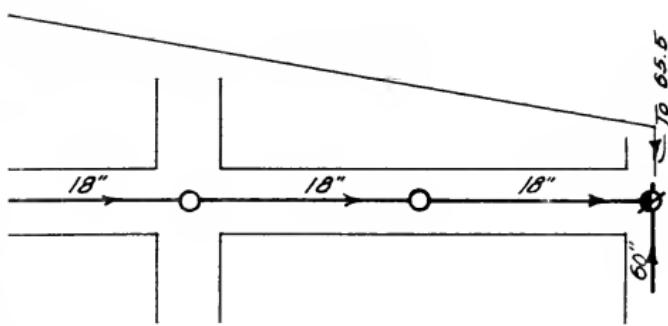
3005

2996

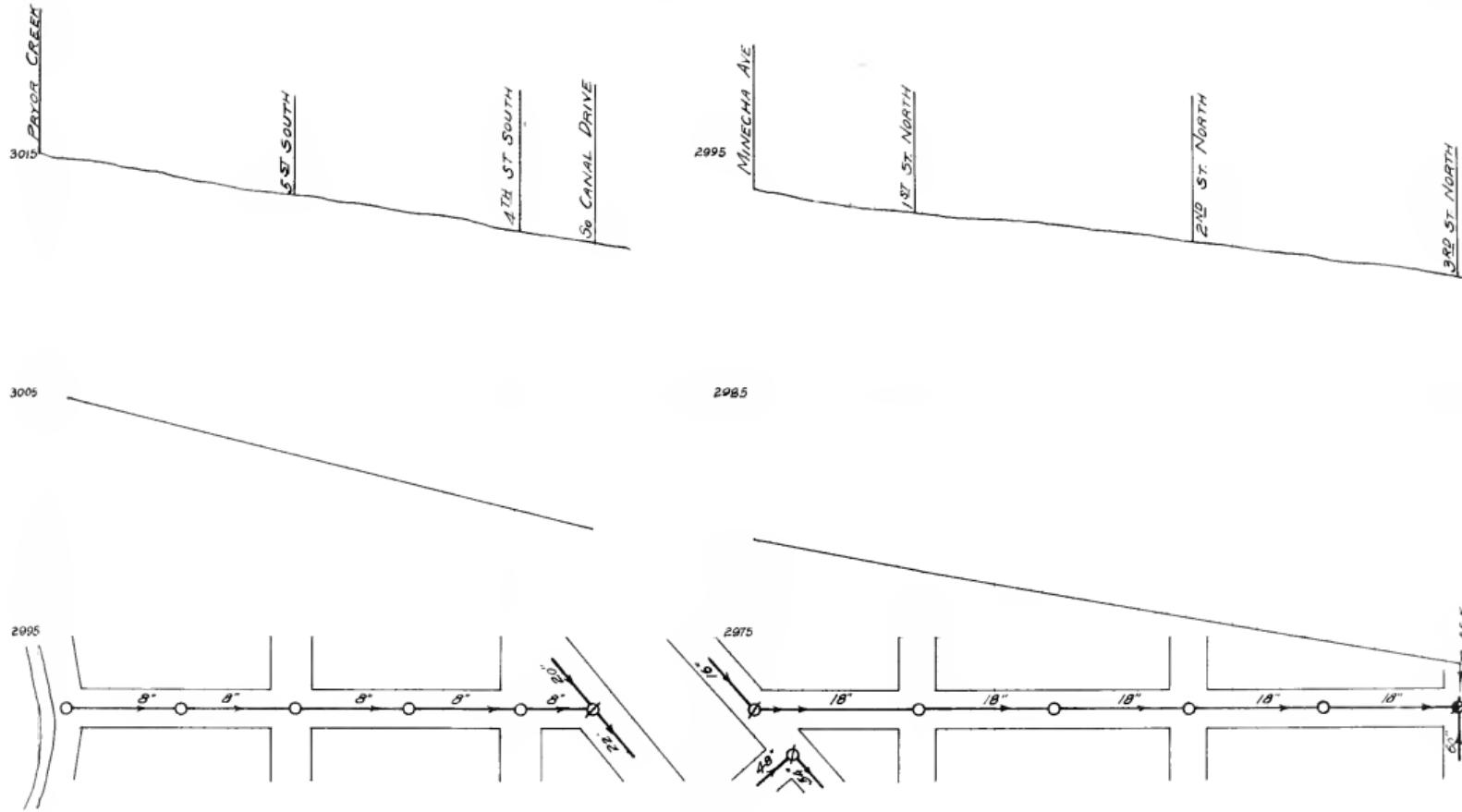
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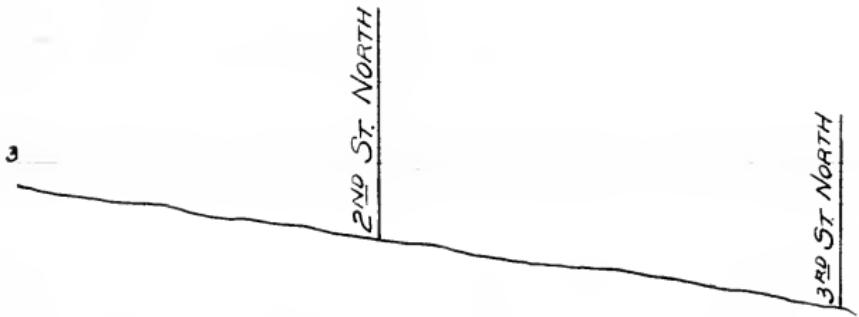
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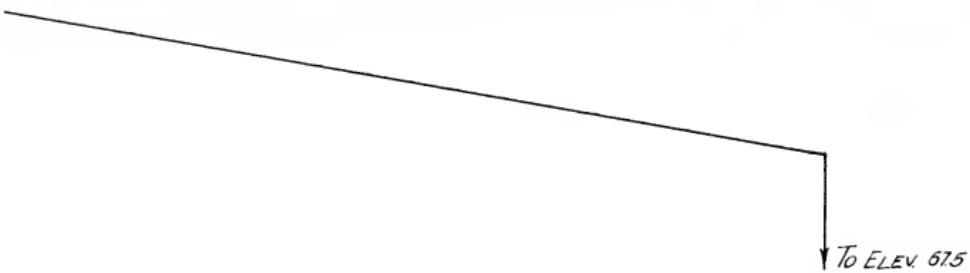
CANE ST.



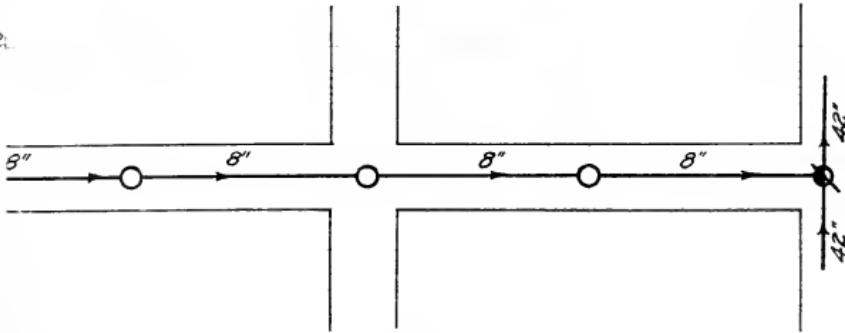
ELM St



31



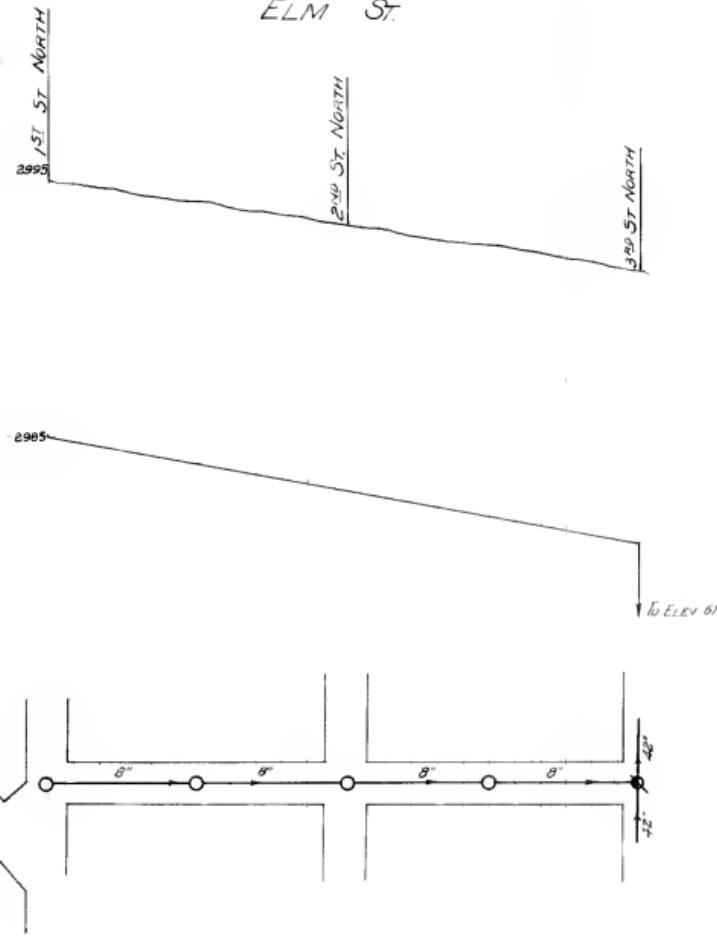
2.



ELM ST

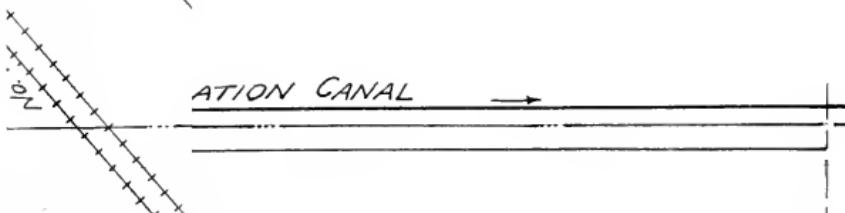
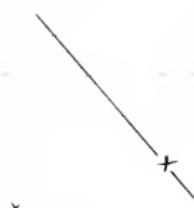


ELM ST.

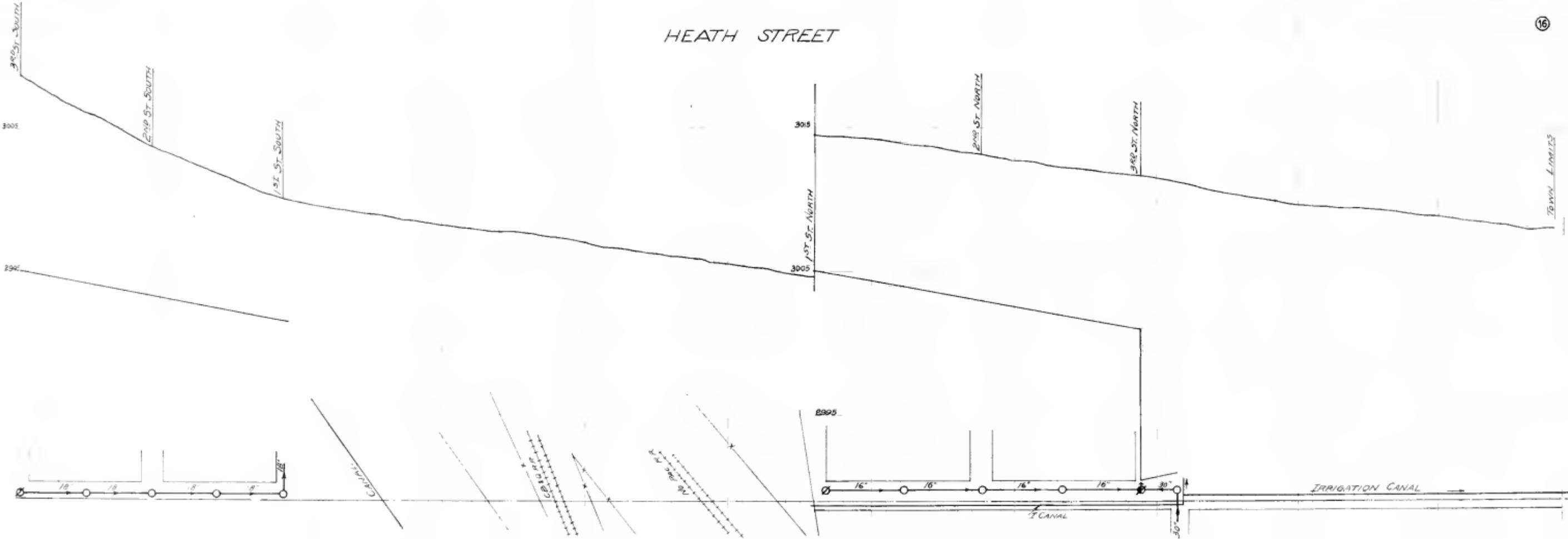


EARTH

TOWN LIMITS

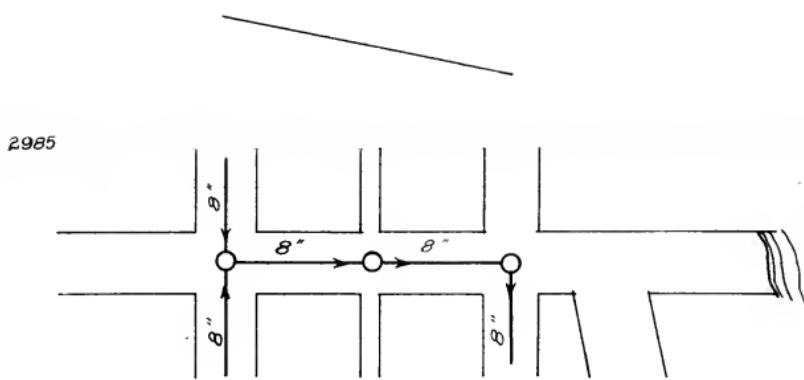
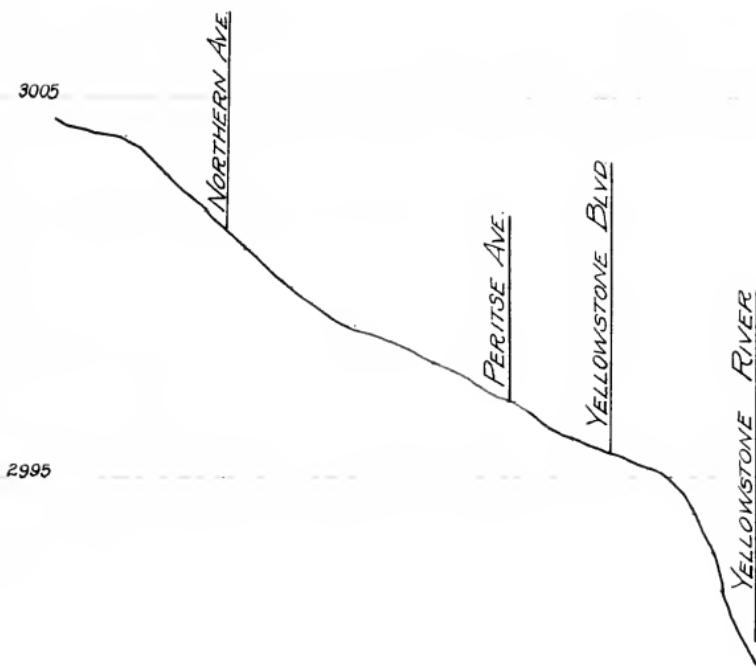


HEATH STREET



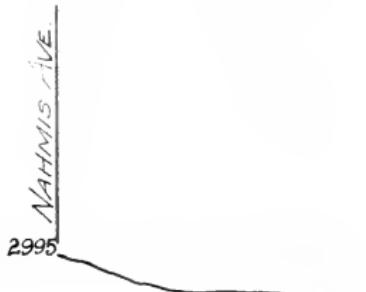
(17)

YELLOWSTONE BLVD.

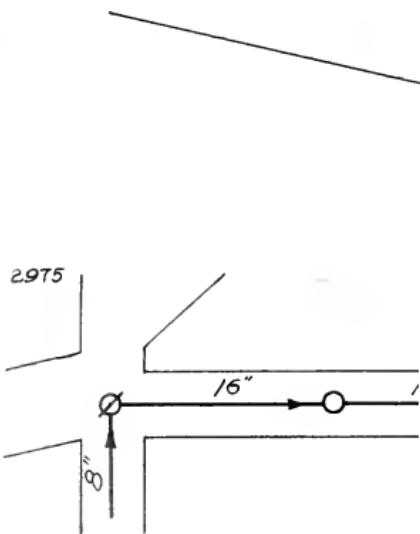


2985

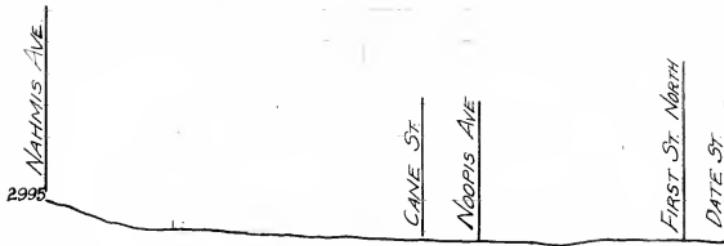
MINEC



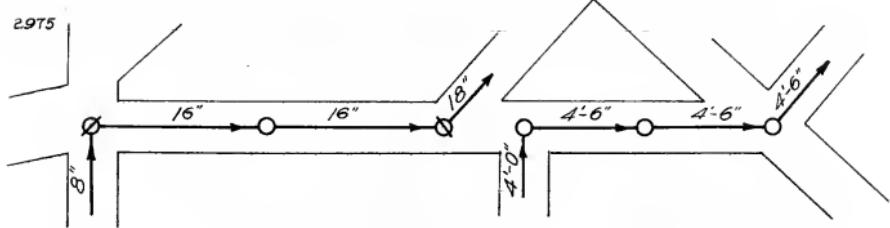
2985



MINECHA AVE.



2985

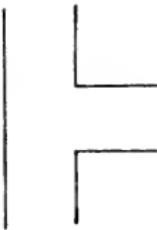




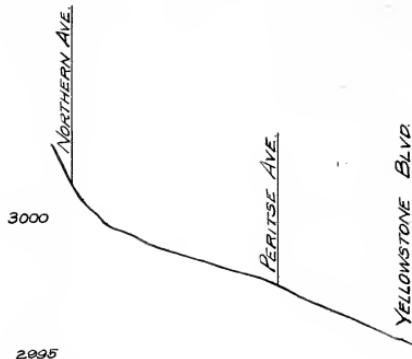
NORTHERN AVE.

3000

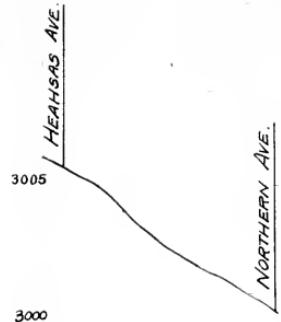
2995



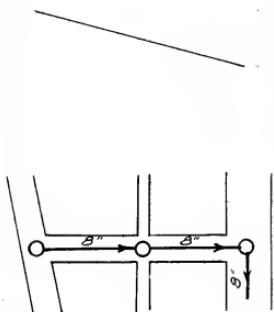
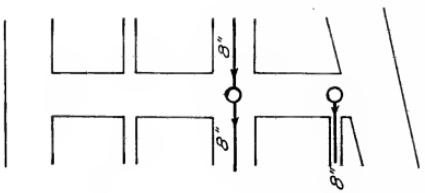


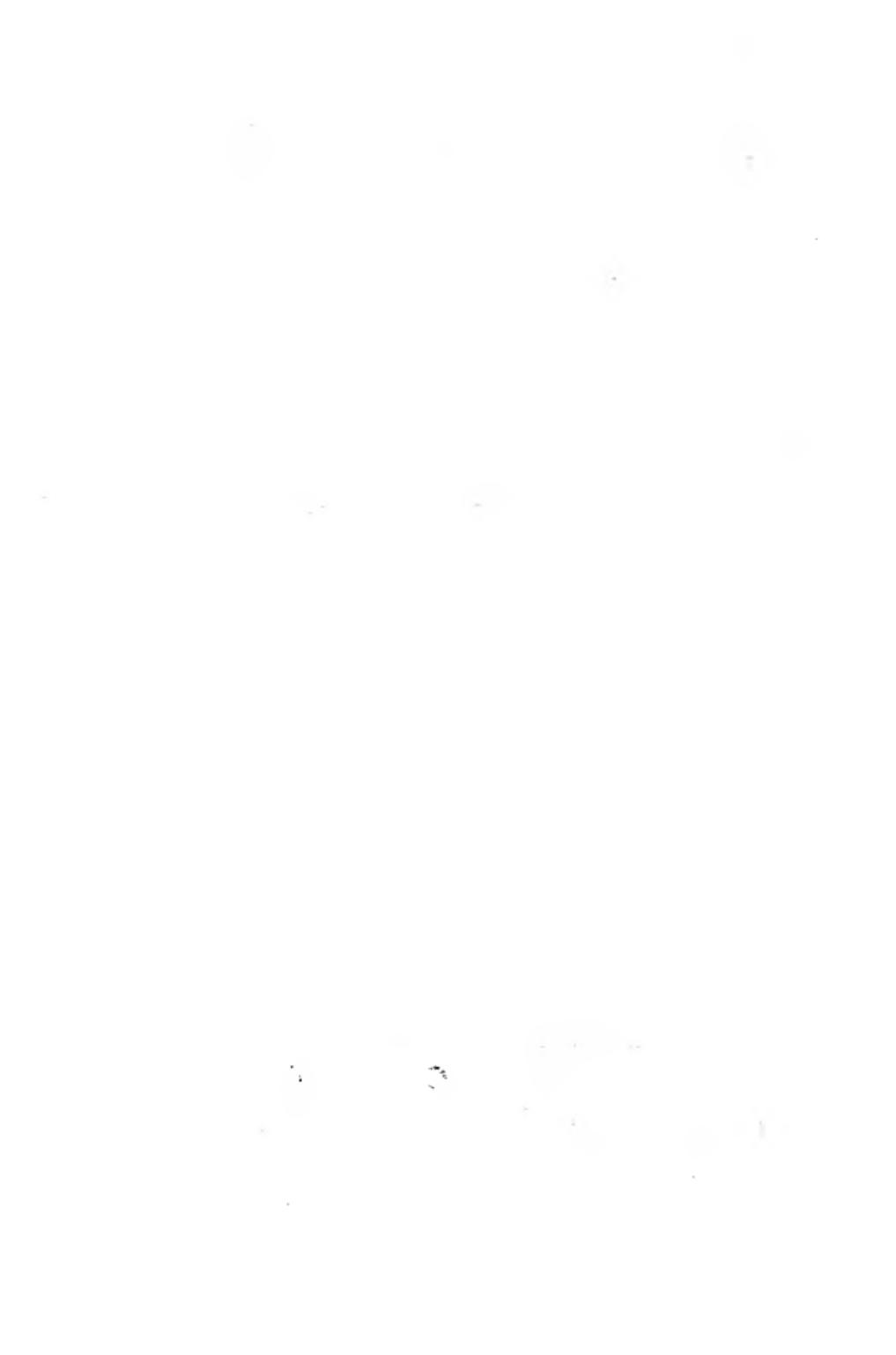


SHOPIS AVE.



RECLAMATION AVE.



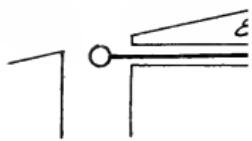


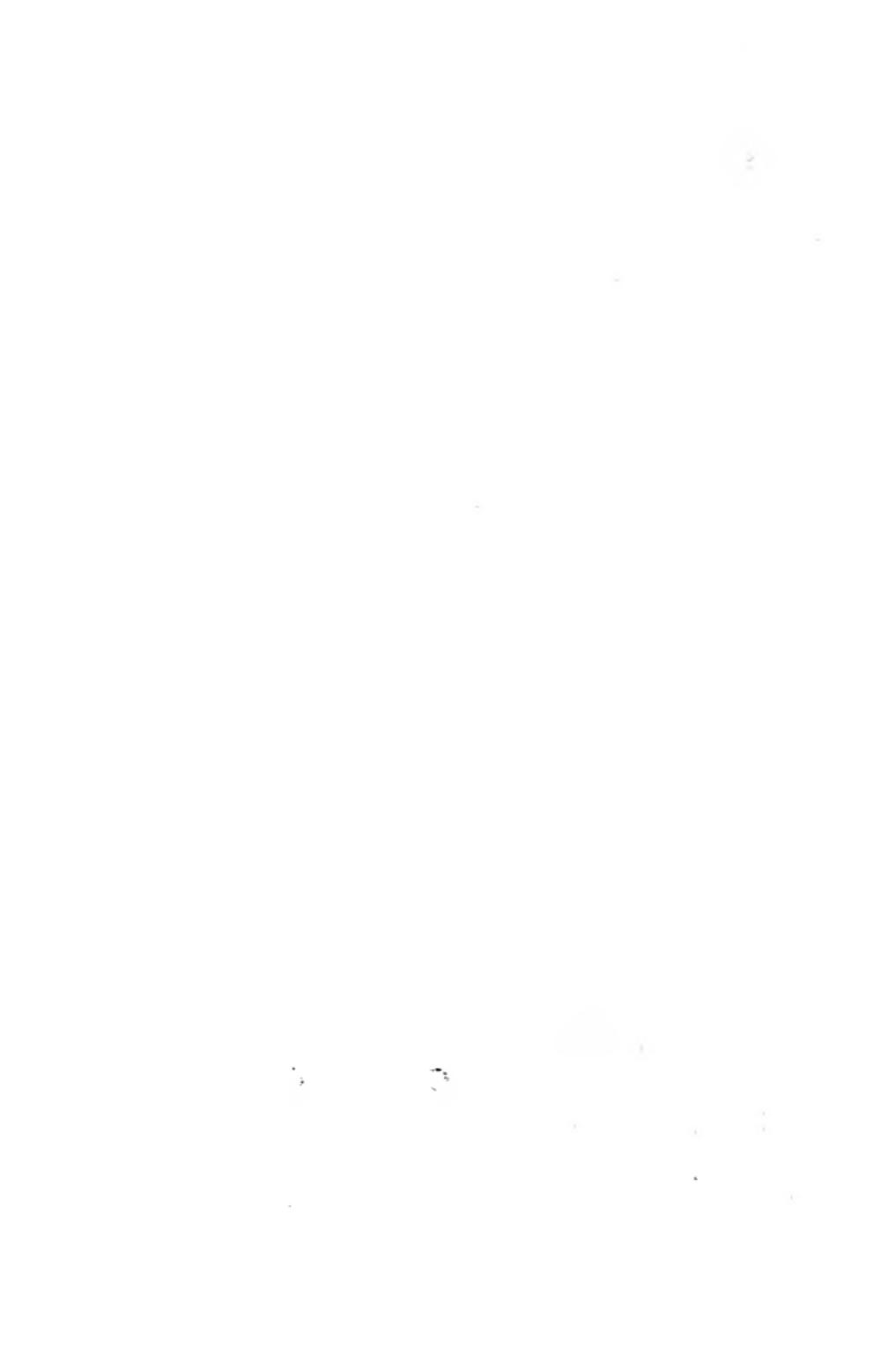
ALL

2995

SHOP IS AV

2985

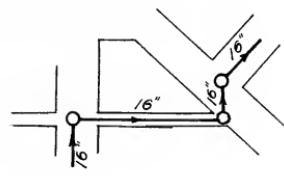
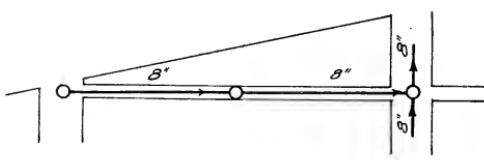
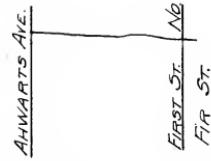




ALLEY NW OF PERITSE AVE.



ALLEY NW OF NORTHERN AVE. (20)

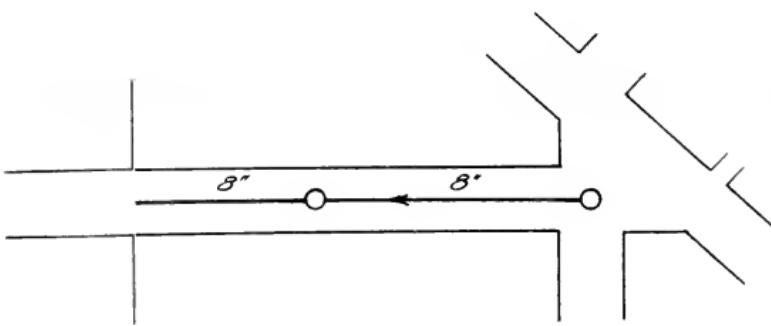


②1

25

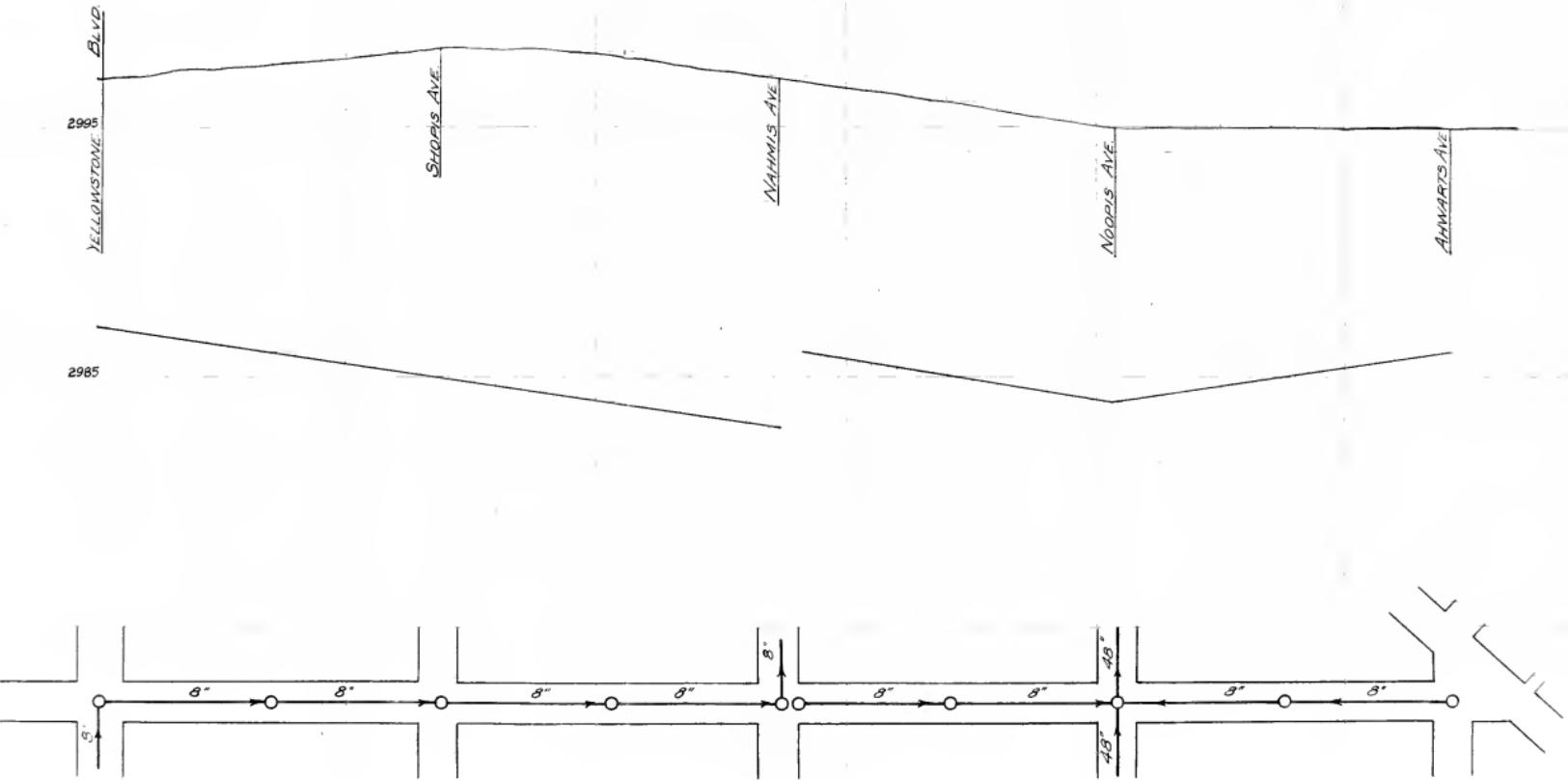
AHWARTS AVE

25

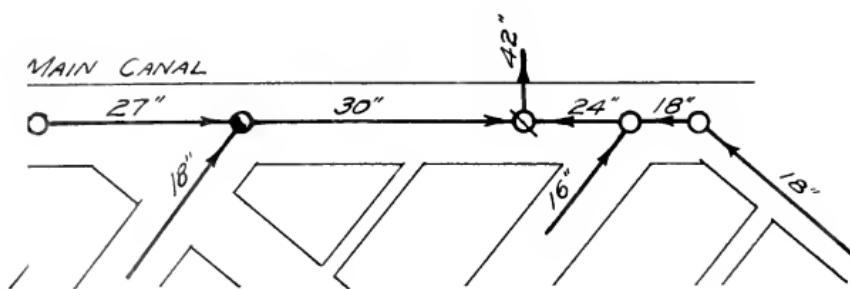
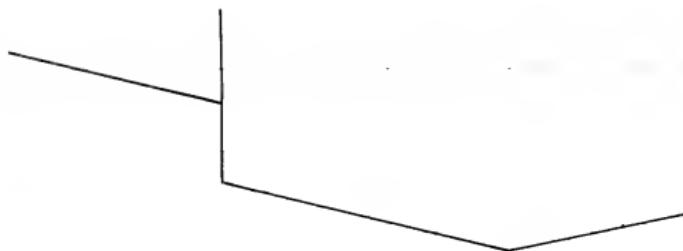
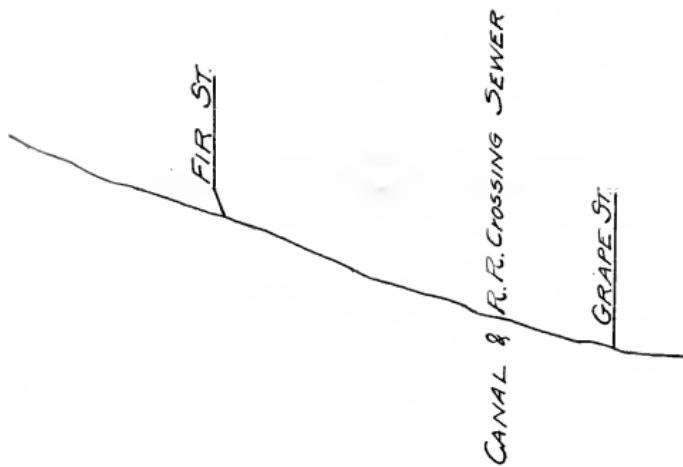


PERITSE AVE.

(21)



22



3012

ST

BEECH

CAVE ST

PINE ST

ELM ST

FIR ST

CANAL & R.R. CROSSING SEWER

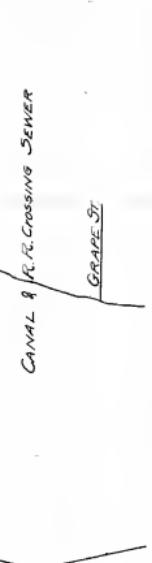
GRAPE ST

3005

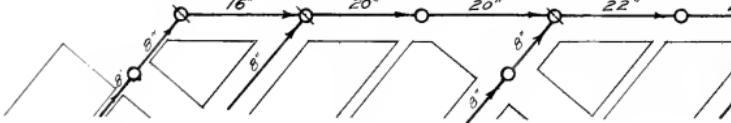
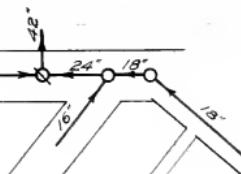
SOUTH CANAL DRIVE

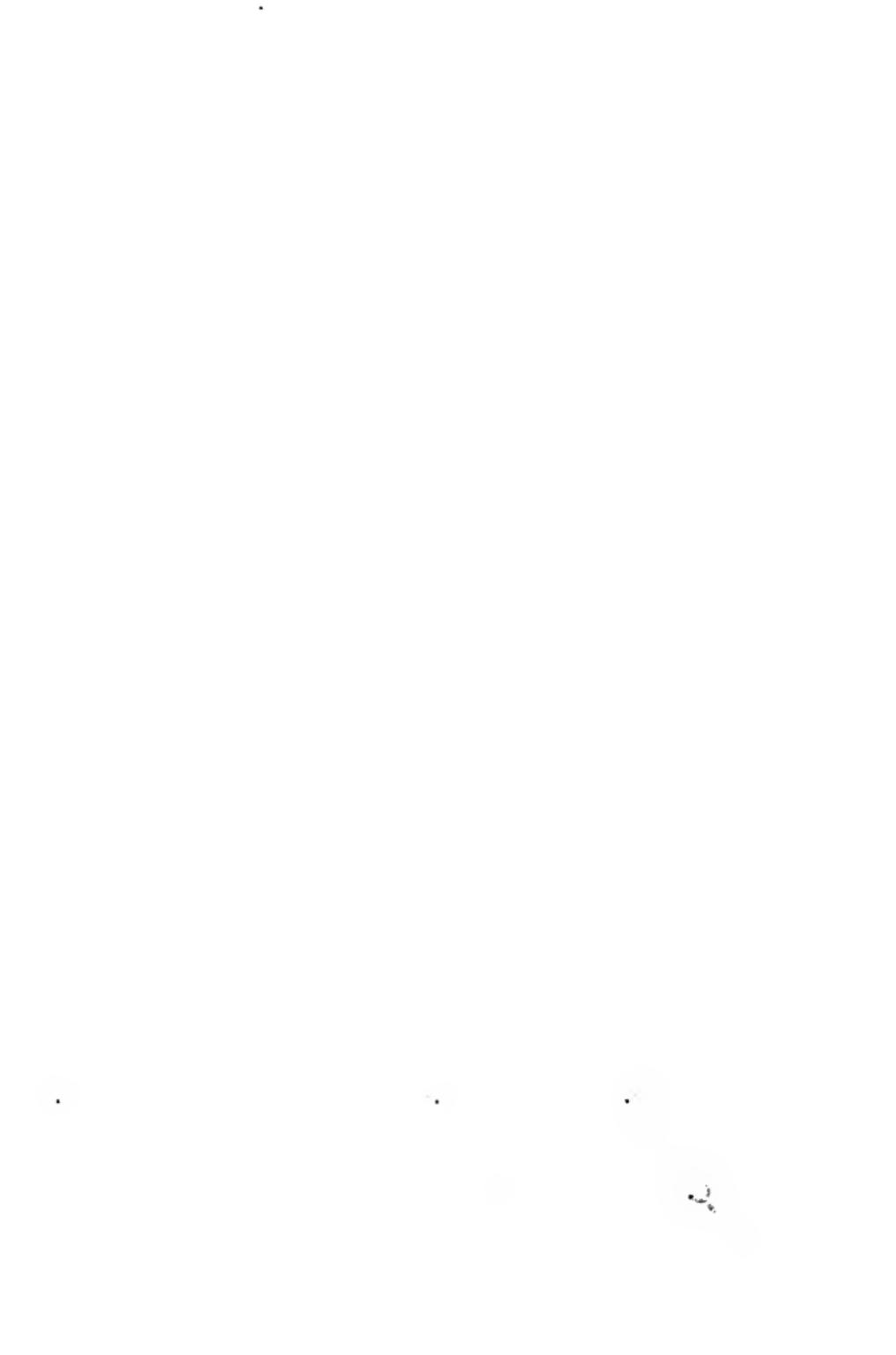
2995

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MAIN CANAL



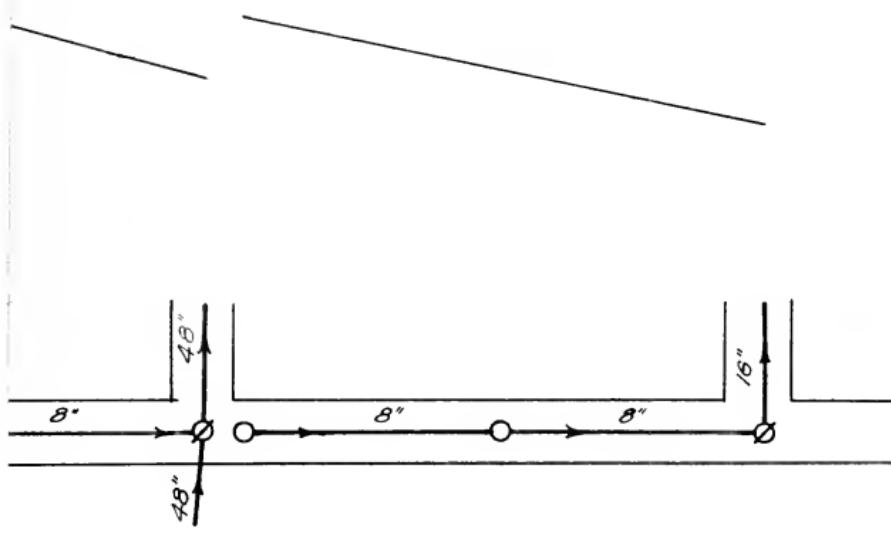


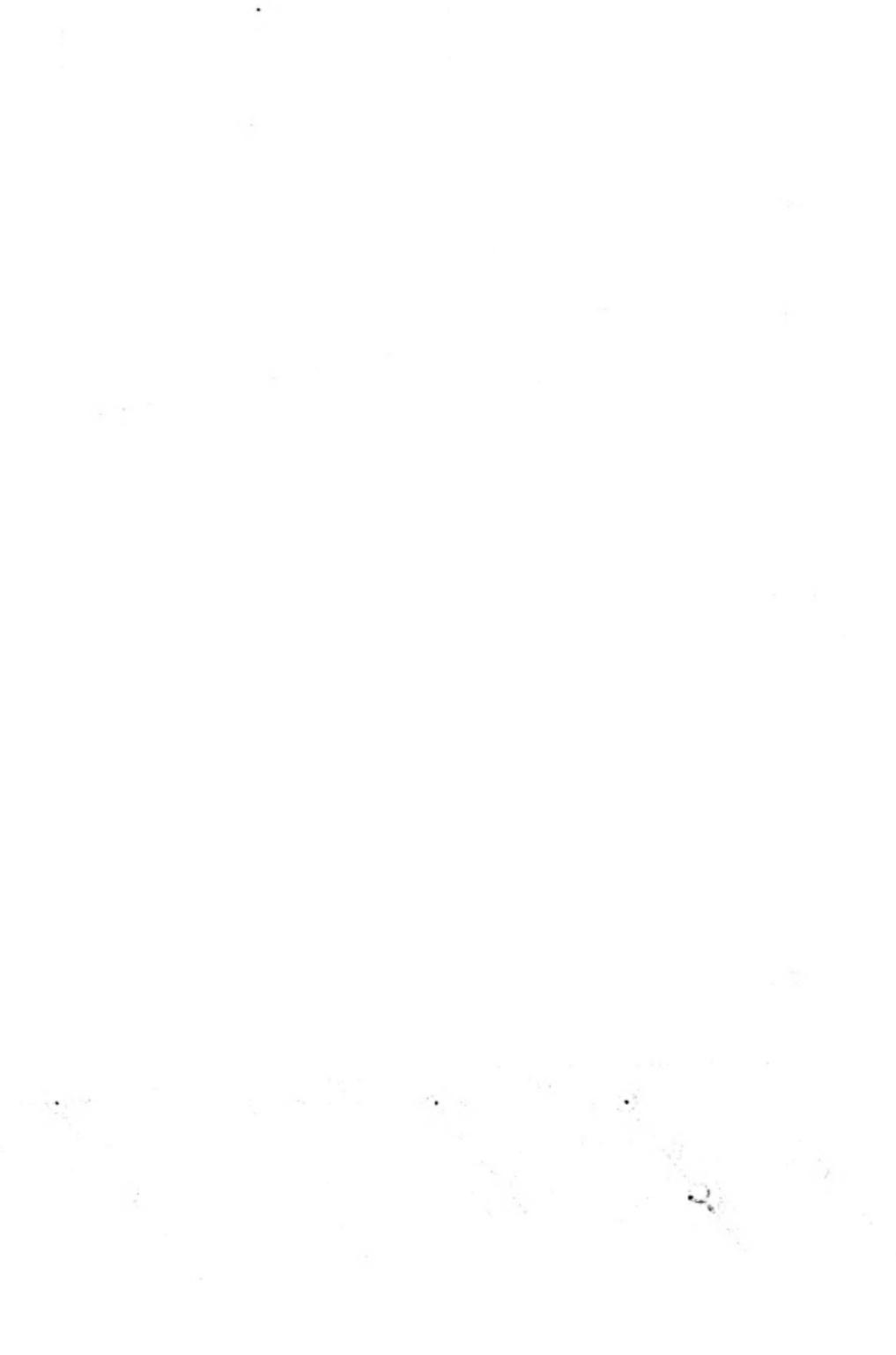
AVE.

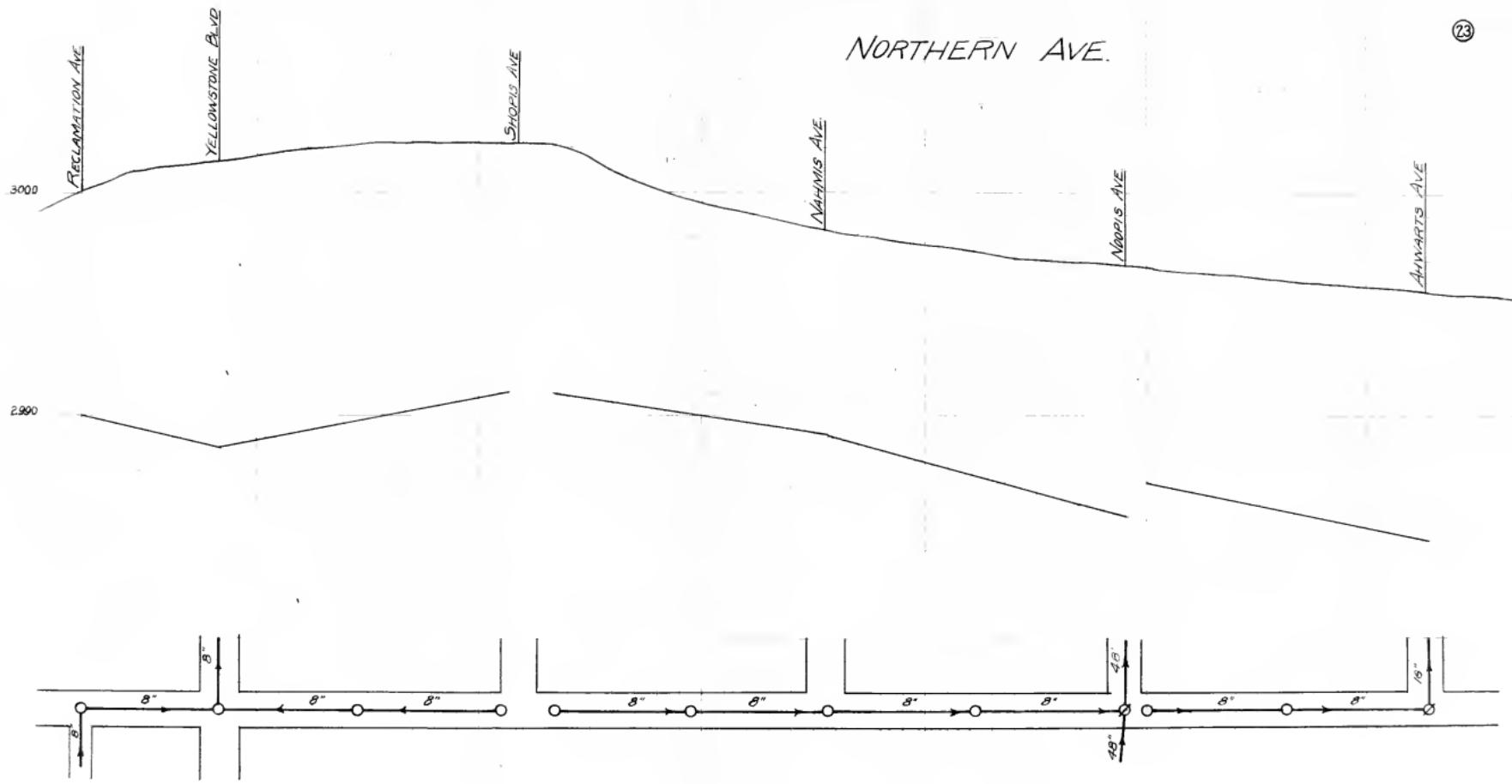
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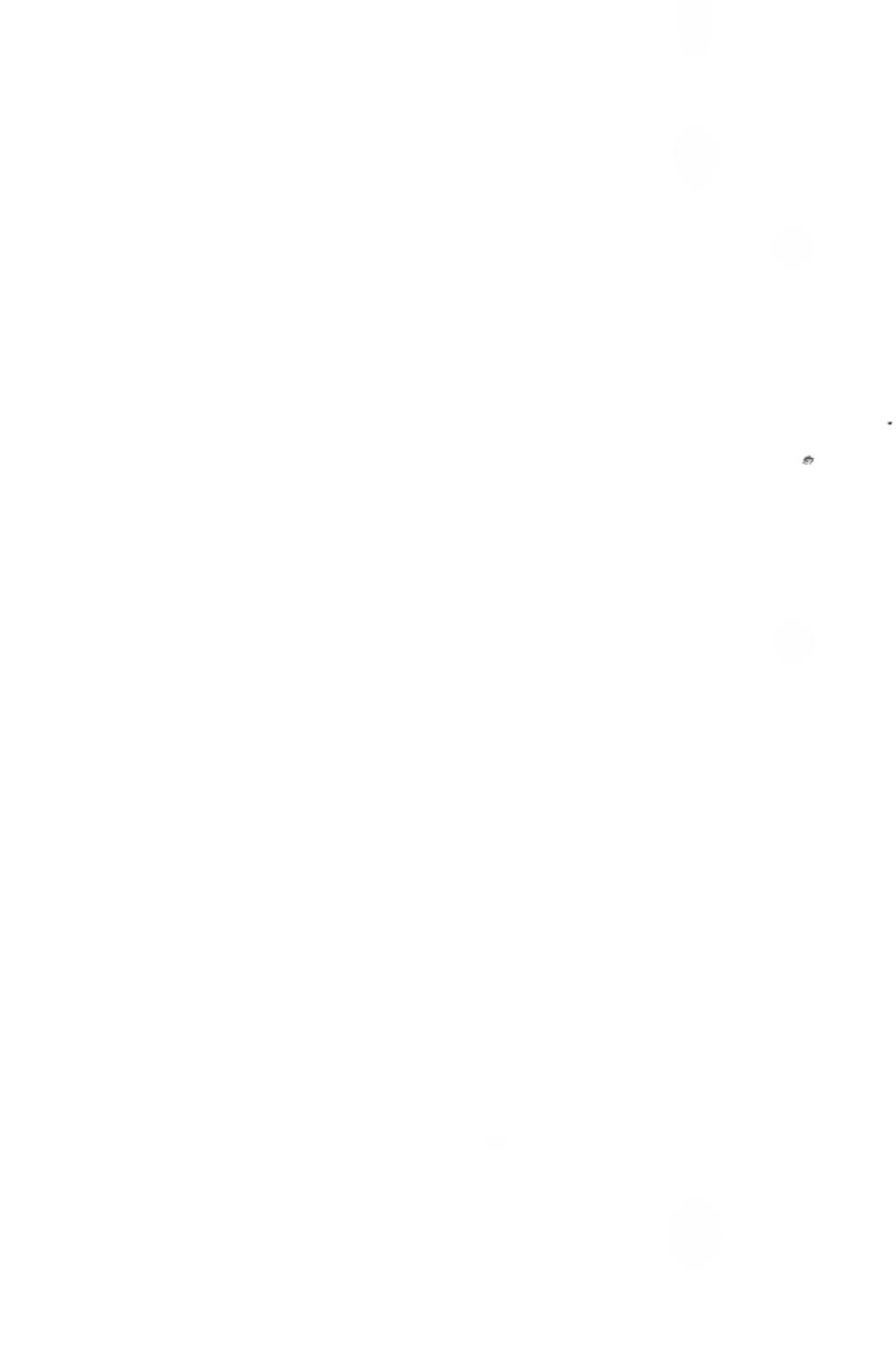
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AWARTS AVE

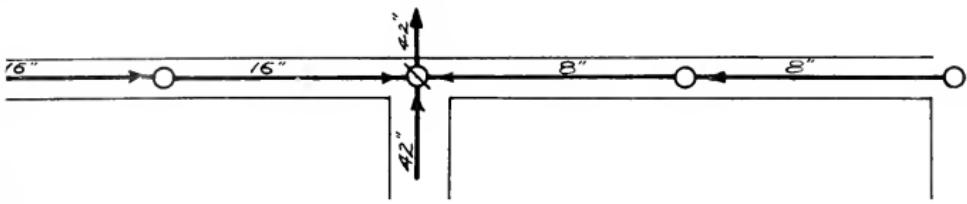








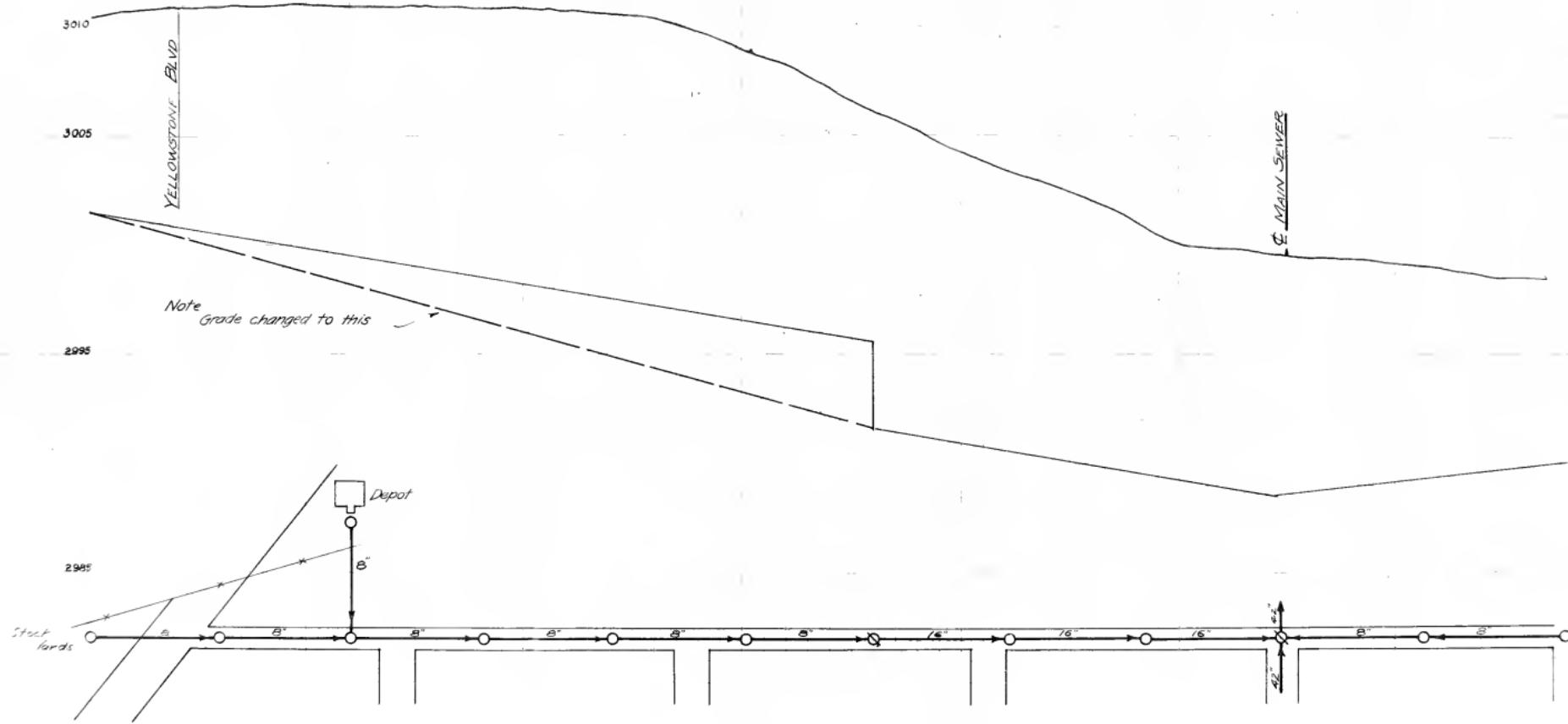
~~MAIN SERVER~~





UNNAMED ST. S.E. OF RR TRACKS

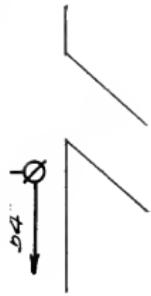
24





MINECHA AVE

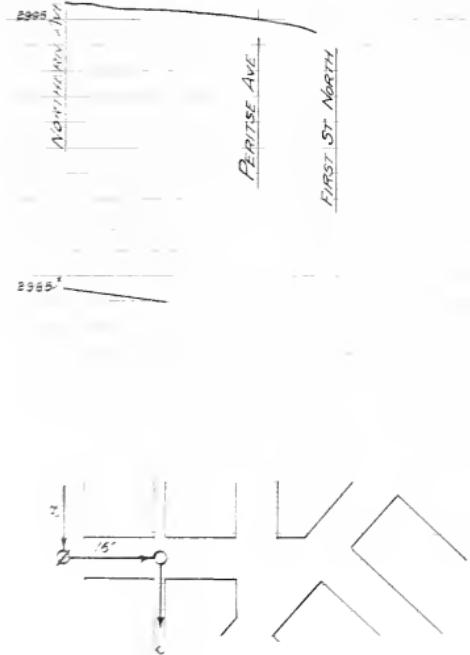
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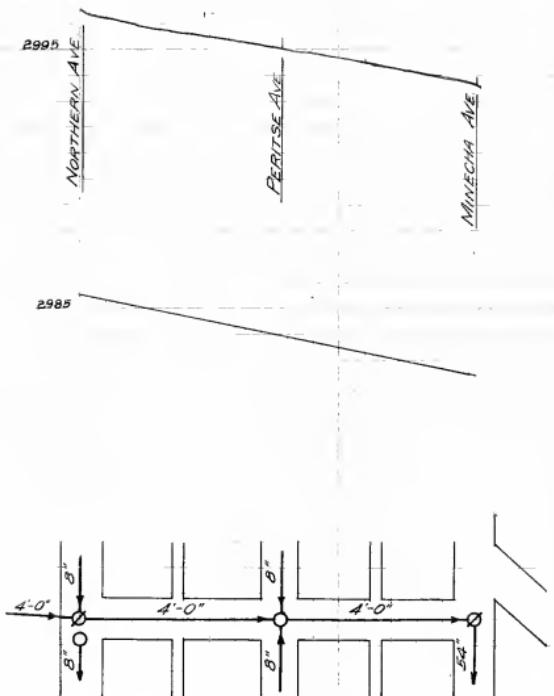
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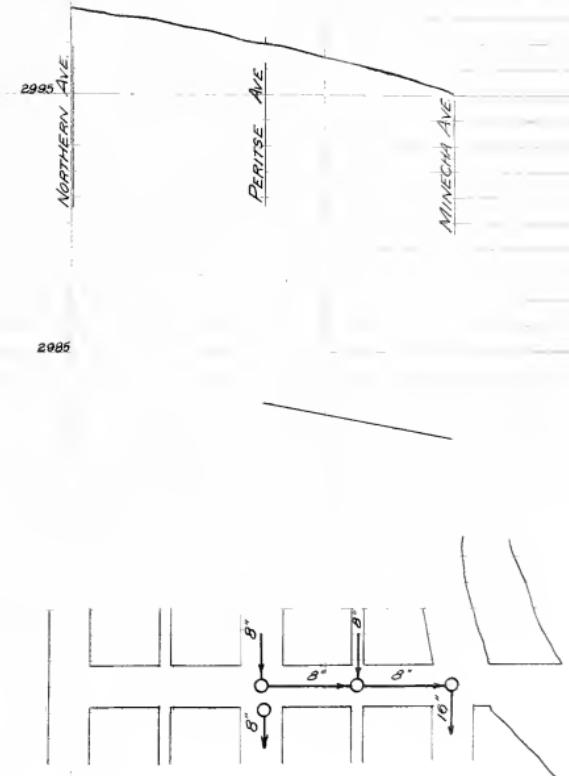
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NOOPIS AVE.



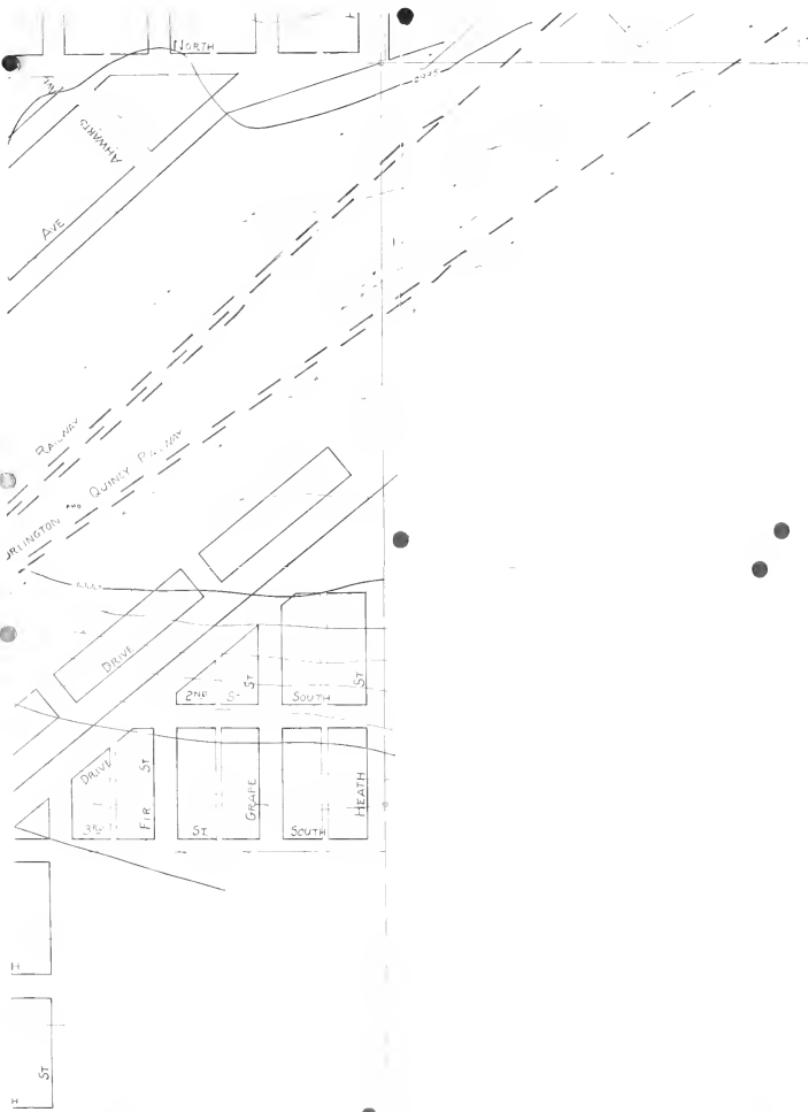
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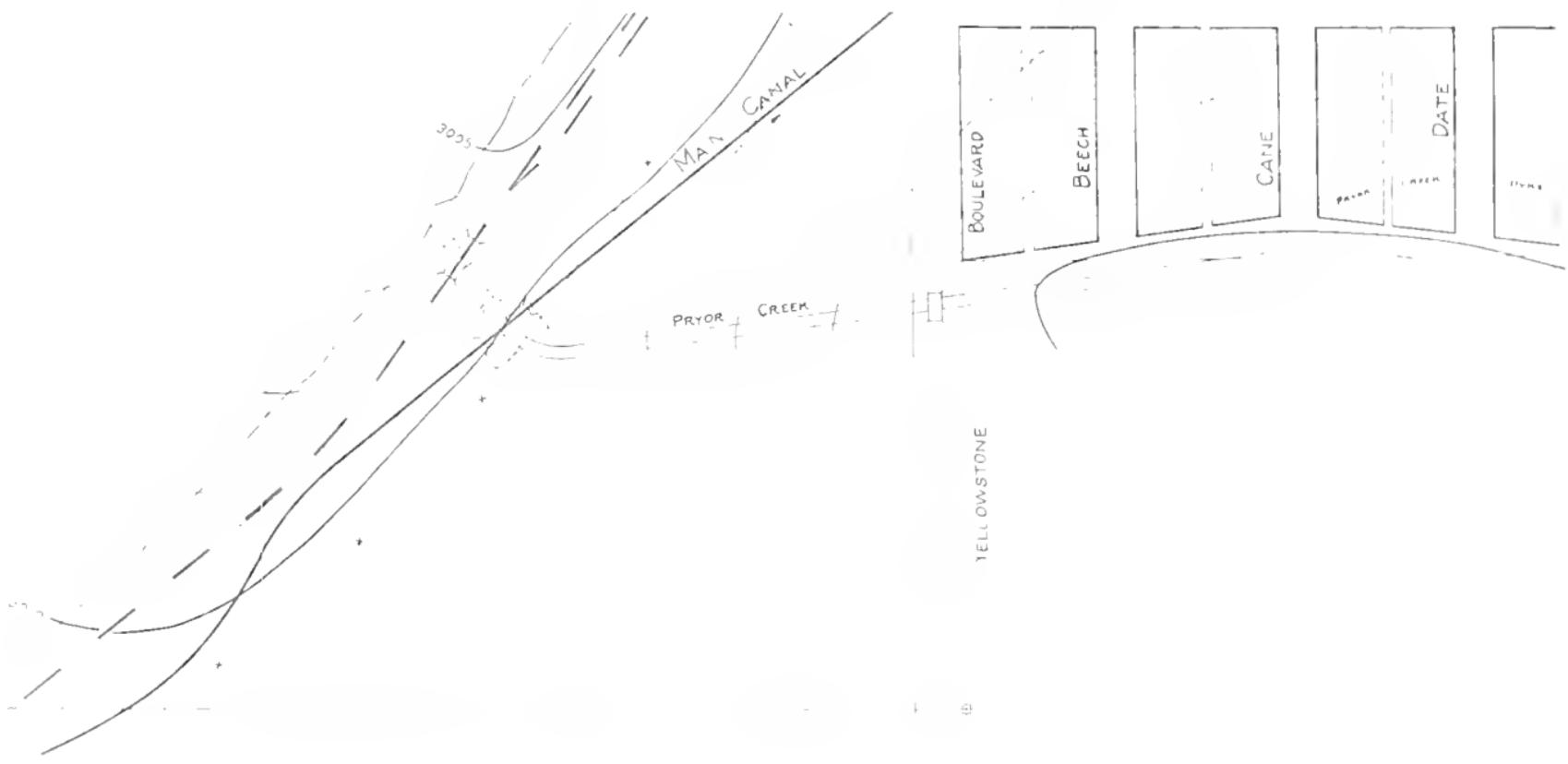


MAP
OF
HUNTER, MONTANA









SEWER SYSTEM
TOPOGRAPHIC MAP

15

ARMOUR INSTITUTE OF TECHNOLOGY

1941

James C. Johnson

James E. Reed





